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GEOLOGICAL SURVEY OF GEORGIA

S. W. McCALLIE, State Geologist

BULLETIN NO. 26

PRELIMINARY REPORT

ON THE

GEOLOGY OF THE COASTAL PLAIN

OF

GEORGIA

BY

OTTO VEATCH,
Assistant State Geologist of Georgia

AND

LLOYD WILLIAM STEPHENSON,
Assistant Geologist, U. S. G. S.

PREPARED IN CO-OPERATION WITH THE UNITED STATES GEOLOGICAL SURVEY UNDER THE DIRECTION OF

T. WAYLAND VAUGHAN,
Geologist in Charge of Coastal Plain Investigations.

ATLANTA, GA.
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GEOLOGICAL SURVEY OF GEORGIA,
ATLANTA, November 1, 1911.

To His Excellency, HOKE SMITH, *Governor and President of the Advisory Board of the Geological Survey of Georgia.*

SIR: I have the honor to transmit herewith a preliminary report on the Geology of the Coastal Plain of Georgia, to be published as Bulletin No. 26 of this Survey. This report, which is the result of co-operative work between the State Geological Survey of Georgia and the United States Geological Survey, brings together in a systematic form all of the data so far collected by these surveys on the stratigraphic geology of the Coastal Plain of this State. By the aid of the information herein given it is now possible to work out to a greater advantage the various problems of economic geology which present themselves in South Georgia.

Very respectfully yours,
S. W. MCCALLIE,
State Geologist.

LETTER OF TRANSMITTAL

WASHINGTON, June 10, 1911.

PROF. S. W. McCALLIE,
State Geologist of Georgia,
Geological Survey of Georgia,
Atlanta, Ga.

SIR: I have the honor to transmit herewith the manuscript of a report entitled "The Geology of the Coastal Plain of Georgia with special reference to the stratigraphy, prepared under the direction of Thomas Wayland Vaughan, by Otto Veatch and Lloyd William Stephenson," in co-operation between the United States Geological Survey and the Geological Survey of Georgia.

This report results from an agreement for the study of the geology and underground water resources of the Coastal Plain of Georgia, entered into by the United States Geological Survey and the Geological Survey of Georgia in 1908. According to this agreement Dr. Vaughan was to have the direction of the investigations, while each co-operating orgainzation was to contribute the services of one geologist until two reports should be completed. One report, on the Stratigraphy of the Coastal Plain of the State, it was agreed, would be published by the Geological Survey of Georgia; while the other report, on the Underground Water Resources of the Coastal Plain of the State, would be published by the United States Geological Survey. The manuscript I am transmitting to you is to be published by the Geological Survey of Georgia.

The Geological Survey of Georgia assigned for this work Mr. Otto Veatch, Assistant State Geologist, while the United States Geological Survey assigned Dr. L. W. Stephenson. Dr. Vaughan has had general supervision of the investigations and he has contributed the determinations of the invertebrate fossils of the Tertiary and Quaternary formations and the inferences as to the correlation of the formations of these two systems. He has also contributed the results of his own field work, which has extended over a period from 1900 to 1910.

Dr. Stephenson is author of the section on the Cretaceous formations. In his paleontologic studies he has had at his disposal, in addition to his own collections, exhaustive collections made by Dr. Stanton in 1891 from several localities on Chattahoochee River, and a number of smaller collections made by other investigators in Georgia. For purposes of comparison he was also given access to the various collections of Cretaceous fossils in the United States National Museum. Dr. Stephenson has also benefited from the suggestions and criticisms of Dr. Stanton, whose wide knowledge of the Cretaceous faunas of North America amply fits him to pass judgment on the work of students of lesser experience. Mr. E. W. Berry, of Johns Hopkins University, has contributed lists of fossil palnts from the Cretaceous formations of Georgia, with annotations, which have been incorporated in the report. Mr. Veatch has supplied numerous unpublished notes on the Cretaceous areas of Georgia, and has also contributed orally much information of value concerning the region. Mr. Veatch has written the chapter on the Physiography of the Coastal Plain, has furnished the list of elevations, has written the introductory chapter on the geology of the Coastal Plain, and is the senior author of the section describing the Stratigraphy of the Tertiary and Quaternary formations. Dr. Stephenson participated in the field work within this area and has aided in the preparation of the manuscript.

Although this report constitutes a decided advance in our knowledge of the geology of the Coastal Plain of Georgia, there is still needed a large amount of detailed investigation. This statement particularly applies to the Tertiary and Quaternary formations. The statements in the report are, in the main, conservative, as it is desired not to claim greater definiteness or precision than the available facts warrant. The mode of treatment of the subject should assist in directing the further investigations of problems concerning which the present information is inadequate.

Very respectfully,

Geo. O. Smith,
Director.

THE

GEOLOGY OF THE COASTAL PLAIN OF GEORGIA

PHYSIOGRAPHY

BY OTTO VEATCH

As an introduction to the study of the physiography of the Coastal Plain the other physiographic divisions of the State will be briefly described. As these other divisions and the Coastal Plain are interrelated in their physiographic history, reference to them will make clearer the account of the geology and topography of the Coastal Plain.

OTHER PHYSIOGRAPHIC DIVISIONS OF THE STATE

Following Hayes' subdivisions of the Southern Appalachian province of the United States, the subdivisions in Georgia are, beginning on the northwest: (1) Cumberland Plateau; (2) Appalachian Valley; (3) Appalachian Mountains; (4) Piedmont Plain. The fifth physiographic division is the Coastal Plain, which, however, is within itself a separate province.

Cumberland Plateau.—The Cumberland Platèau is made up of flat-topped mountains or tablelands of Carboniferous strata, and occupies, in Dade and Walker counties, a small area which has an elevation of 1,500 to 2,300 feet above sea level. It is represented in Georgia by Lookout, Pigeon, and Sand or Raccoon mountains. These mountains rise 700 to 1,400 feet above the valleys, and are characterized by comparatively flat tops and have steep, precipitous sides; they owe their form to the resistant character and synclinal structure of the rock capping them.

Appalachian Valley.—The Appalachian Valley lies between the Cumberland Plateau on the west and the Appalachian Mountains on the east. Considered as a whole it is a valley, since it is lower than the regions both to the east and west, but within itself it is a region of parallel ridges and corresponding subordinate valleys. The valley is 40 to 50 miles wide, extends from the Tennessee line to the southern part of Polk County and across the State into Alabama. It is limited on the east by an abrupt scarp of semi-crystalline schists of the Appalachian Mountain area, the Cartersville fault line. The province lies within the Paleozoic area and is in a region of intensely folded limestones, sandstones, and shales. The ridges have a north-south direction, are generally steep-sided and owe their existence both to the structure and the resistant character of the rock composing them, while the valleys have been eroded from the softer strata. The valleys have an elevation above sea level of 600 to 900 feet and the ridges, 1,000 to 1,800 feet.

Appalachian Mountains.—The Appalachian Mountains area is composed mainly of the Blue Ridge, with lesser mountain groups, both to the east and west. The area occupies the northeastern part of the State; it is roughly delimited on the south by a line from Clarkesville to Marietta, thence west to Rockmart, Polk County. The Blue Ridge enters the State in Rabun and Towns counties and loses its distinctively mountainous character in Pickens County. As contrasted with the Appalachian Valley and Cumberland Plateau, the region is one of vastly greater rock complexity, composed of igneous rocks and highly metamorphosed sediments, that have been subjected to great orogenic movements, intense folding and faulting, and erosion since early geological periods. The topography is more rugged, and there is a greater complexity of topographic forms, irregularity of drainage form, and less dependence of ridges upon the strike of the rock. The highest elevation above sea level is about 5,000 feet, while there are a large number of "balds" or knobs which are above 4,000 feet.

Piedmont Plain.—The Piedmont Plain lies between the Appalachian Mountains and the Coastal Plain. This is a southward sloping plain ranging in elevation from about 1,200 to 300-400 feet above sea level. The region is one of great rock complexity like that of the Appalachian Mountain area, and the beds have been subjected to intense folding and faulting, but the surface has been planated by erosion, and with the exception of a few conspicuous elevations the land presents an even sky line. The streams generally conform to the slope of the plain, and have deeply trenched their courses, pro-

ducing a broken, or hilly topography, in places approaching mountain ruggedness, but the tops of the hills and ridges always present a level.

COASTAL PLAIN OF GEORGIA

The Georgia Coastal Plain includes that portion of the State lying south of the Piedmont Plain. The contact between these two divisions is known as the Fall Line. This is a somewhat indefinite line which derives its name from the falls or rapids in the rivers at the places where they pass from the Piedmont crystalline rocks to the softer and less resistant rocks of the Coastal Plain. In Georgia this line extends in a northeast-southwest course from Augusta through Milledgeville and Macon to Columbus. The "falls" are not precipitous and are indicated by a series of rapids. There is a merging of the topography and the railway traveler in passing from one area to the other rarely recognizes the contact, which is more geological than topographical. That is, no prominent topographic feature separates the two regions.

The Coastal Plain has an area of about 35,000 square miles if it is considered as confined to the area underlain by Cretaceous and later sediments, but considered purely as a physiographic division, it would perhaps include a portion of the crystalline area or represent the original extent of the Coastal Plain beds and would then have an area between 36,000 and 37,000 square miles.

Physiographically, the region is a low plain having a gentle southward tilt. In contrast to the other physiographic divisions of the State it has been subjected to the forces of erosion for only a comparatively short time, and its topography over the greater part of the area may be described as *youthful*. On the whole, the Coastal Plain is level, although there are some hilly and broken areas in the northern part; the plain is dissected in places near the Fall Line, and the topography has a somewhat more mature aspect. The hills, however, never rise above a general level and their tops always present an even sky line. The rocks are mainly unconsolidated, sands, clays, and marls, and their structure is simple. There is consequently an absence of pronounced topographic features due to resistant varieties of rock and the folding of beds, such as characterize the Appalachian Valley and Appalachian Mountains. The plain reaches a maximum elevation of 650-700 feet between Macon and Columbus, and 500-600 feet between Macon and Augusta, and thence slopes gradually at the rate of about three or four feet per mile to sea level. About one-half of it has an elevation of less than 300 feet, while a large area near the Atlantic coast, about one-seventh of the total, is less than 100 feet above sea level. The streams on the whole have

not cut as deep courses as in the older divisions; tributary streams are fewer, and there are large areas, flat and undrained or but poorly drained, particularly in the southeastern part.

While the Coastal Plain may be described as a low, level plain, in comparison with the Appalachian Valley, Appalachian Mountains and Piedmont Plain, it is not entirely featureless and within itself presents topographic contrasts. The writer has made the following physiographic divisions: (1) Fall Line hills; (2) Dougherty plain; (3) Altamaha upland; (4) Southern lime-sink region; (5) Okefenokee plain; (6) Satilla coastal lowland. The location and extent of these divisions may be seen by reference to the map below.

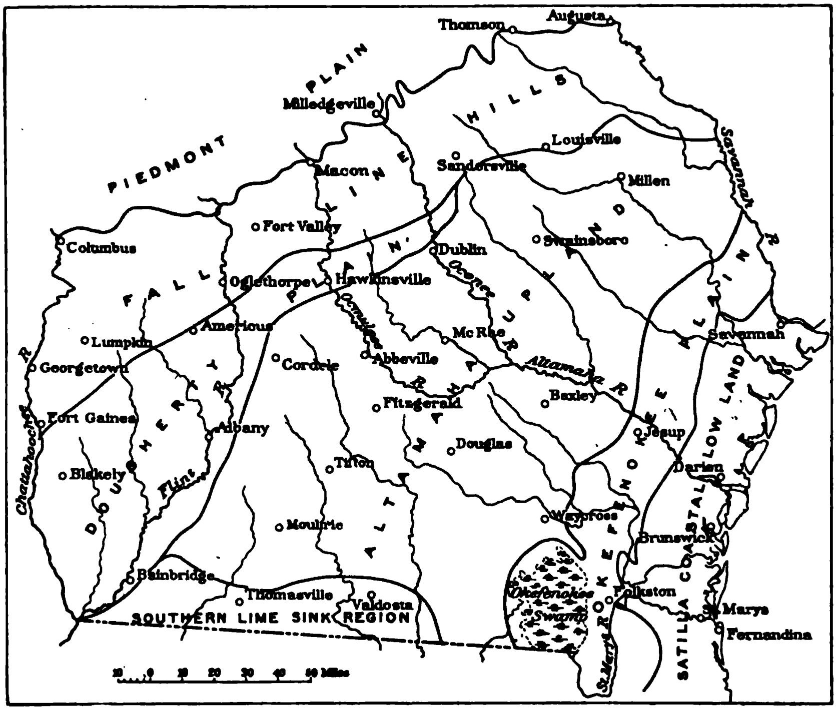

Fig. 1.—Sketch map showing physiographic divisions of the Coastal Plain of Georgia.

FALL LINE HILLS

The Fall Line hills division, as the name indicates, occupies the upper portion of the Coastal Plain. The northern extent is that of the Coastal Plain sediments, or approximately the Fall Line, south of which it forms a belt 40 to 50 miles wide, entirely across the State.

It can not be sharply defined, as on the north the topography merges into that of the Piedmont Plain and on the south into the level and less broken land of the Dougherty Plain and the Altamaha Upland. In this region, more than in any of the other divisions, the topographic features are due to surface erosion. Stream erosion is more active on account of the greater altitude and has been in progress for a greater period of time. The region is characterized by flat-topped hills or ridges and deep gullies or "washes." The larger streams have cut courses 200 to 350 feet below the level of the upland plain and the northern portion of the belt is as broken as the adjacent Piedmont Plain. The region is underlain mainly by sands and clays of the Cretaceous and Eocene and their softness has been favorable for rapid erosion.

In elevation above sea level the higher land west of the Ocmulgee River varies from approximately 350 to 700 feet; that east of the Ocmulgee, from 300 to 600 feet. The elevations of low water at Columbus, Macon, Milledgeville and Augusta are respectively: 190, 278.6, 241.29, and 98 feet.

Two types of hills are commonly recognized, the *sand hills* and the *red hills*. The sand hills are best developed in the upper part of the belt and are conspicuous in Richmond, Crawford, Taylor, Talbot, Marion and other counties, and are really no more than flat ridges which have a notable covering of gray or brownish, superficial sand. The sand is almost pure quartz, incoherent or loose, and varies in thickness from three or four to twenty or thirty feet, but the average thickness over the sand hills is perhaps not more than five or six feet. This sand is probably residual from the underlying Cretaceous and Eocene formations. (See p. 451.) The soil is poorly productive, and the tree growth is mainly stunted oak and scattered long-leaf pine.

The lower portion of the Fall Line hills belt is mainly *red hills*, and the gray superficial sand is less widely distributed. The soil of these hills is a bright red sand or red, sandy loam, which is residual from the underlying geological formations, chiefly the Eocene. The red hills are conspicuous in Wilkinson, Twiggs, Houston, Macon, Sumter, Terrell, Randolph, and Stewart counties.

The deep gullies, also known as "washes" and "caves," which appear in this region, are worthy of note. The softness of the strata together with the high altitudes of the plain above the rivers, timber denudation, and cultivation of the land, have been especially favorable for rapid erosion, and some of the deepest gullies, 100 to 175 feet, are known to have formed since the settlement of the country. Perhaps the largest and most picturesque of the gullies are located

west and north of Lumpkin, Stewart County. The gullies at Providence, eight miles west of Lumpkin, are 100 to 175 feet in depth, and from 200 yards to one-fourth mile in length. The greatest width is at the head, due to the union of a number of tributary gullies, so that a plan of the upper edge would be roughly bottle-shaped or pear-shaped. A transverse profile would be V-shaped; a longitudinal profile would be roughly L-shaped, the horizontal line of the letter, of course, greatly exceeding in length the vertical line. That is, the head of the gully is precipitous and the gradient of the floor so low that the water which flows through the gully is unable to carry the load of sand which is washed down, and it is spread out as deltas and "sand streams." An excellent illustration of a "sand stream" is shown in plate XIV, B, opposite page 160. The strata are unconsolidated sand, containing soft clay layers, and are hence, easily eroded. The recession of the gullies has been very rapid, and the deepest gully is known to have worked back 300 feet in about 30 years, and to have washed out a space of 10 or 15 acres. As much as five or even ten feet "cave" or slump at one time after very heavy rain storms. These gullies are the most picturesque features of the Coastal Plain, presenting curious erosion forms, pinnacles, "islands," or blocks of strata cut off from the adjacent land by erosion, and sharp serrated ridges, while the bright red and white sands and the dark green pine tops present a vivid color contrast. Similar deep washes or gullies appear in Quitman, Webster, Marion, Crawford, Houston, Twiggs, Wilkinson, and Washington counties. The deep washes on the south side of Rich Hill, Crawford County, are, next to the Providence gullies, perhaps the most picturesque. The famous Lyell gullies four miles west of Milledgeville are properly within this area, although they are cut entirely in residual clay derived from granite, since a few remnants of the Coastal Plain sediments appear at this locality. The gullies are about 50 feet deep. They were visited by Sir Charles Lyell in 1842, and subsequently described in his "Travels in North America."

DOUGHERTY PLAIN

This division occupies a large area in the western part of the Coastal Plain. It is characterized by very level tracts, and there are few elevations that may properly be termed hills; it is a region in which there are comparatively few small streams and branches and consequently one in which there is little surface erosion, the drainage being in large measure subterranean. It is further characterized by numerous lime-sinks, which form shallow depressions in otherwise level tracts. This division extends from the Chatta-

hoochee to a few miles east of Flint River, and includes the greater part or all of the counties of Decatur, Miller, Mitchell, Early, Baker, Calhoun, Dougherty, Randolph, Terrell, Lee and Sumter. A small strip extends eastward from the Flint to the Oconee, including parts of Dooly, Houston, Pulaski, and Laurens counties, and includes most of the area underlain by the limestones of the Vicksburg formation. It is rather sharply differentiated from the Altamaha Upland on the east and south, but merges into the Fall Line hills on the north.

In elevation above sea level it varies from approximately 125 feet in Decatur County to 450 feet in the southern part of Houston County. Much the greater portion of the area is less than 300 feet.

Due to the extensive underground solution of the soft underlying limestone, lime-sinks are very numerous and characteristic of the region. These vary in size from small, shallow depressions not more than 100 to 200 feet in diameter to those occupying several hundred acres and to chains of sinks several miles in extent. The sinks usually contain water, forming shallow ponds or lakes, and the shallow ponds usually contain a thick growth of cypress and other trees. The amount of water in the ponds and lakes varies with the seasons, and during droughts the smaller ones become dry. The recent desiccation of the sinks is also partly attributed to the removal of timber, thus permitting increased evaporation and oxidation of organic matter. Sinks are also known to have been suddenly drained through subterranean passages.

The absence of numerous small tributary creeks and branches is due not so much to the newness of the land surface as to the fact that a large portion of the drainage is through subterranean streams. Most of the large creeks flow sluggishly through wide, swampy valleys, and rarely have any considerable bluffs along their courses. Chattahoochee, Flint and Ocmulgee rivers have cut deep, terraced valleys 75 to 200 feet below the plain, but have comparatively few tributary streams.

ALTAMAHA UPLAND

This area constitutes the largest physiographic division of the Coastal Plain. Its northern boundary is marked by an irregular line between Waynesboro, Tennille, Dublin, Cochran, and Vienna, its western edge thence lying parallel to and a few miles east of Flint River and extending to Decatur County. On the southeast it extends into Effingham, Liberty, Wayne, Pierce, Ware, and Clinch counties, and merges into the sandy pine flats of the Okefenokee Plain. It embraces most of the region popularly known as the

"wire-grass country," and is underlain mainly by the Altamaha (Lafayette?) and Alum Bluff formations. The geology, topography, and flora of this region are of peculiar scientific interest and have been the subject of a number of papers and articles.[1]

The region is an *upland* only in comparison with the low coastal plains on the southeast and the adjacent Dougherty plain on the west, and on the whole is lower than the Fall Line Hills to the north. It varies in elevation above sea-level from about 125 to 470 feet. It reaches the highest elevation on the north and west, thence there is a gradual slope southeast. There is a steep ascent or escarpment on the west, separating it from the Flint River lowland, which is prominent enough, even in this region of low relief, to be distinguished by the observant traveler without the aid of topographic maps. For example, the rise from Camilla to Pelham, Mitchell County, over the Atlantic Coast Line Railroad is 185 feet in a distance of eight miles, and the rise from Bainbridge east to Climax is 175 feet. Arabi, Crisp County, Ashburn, Sylvester, Pelham, and Climax may be considered as marking approximately the crest of the escarpment; thence there is a decrease in elevation to the southeast.

A characteristic of the topography is low, rolling hills, with smooth or softened outlines, which do not rise except along the large rivers more than 40 or 50 feet above the valleys. There is an absence of any features suggesting ruggedness, yet at the same time the region is not a monotonous level or flat.

The soil is generally sandy and in places there is a thick mantle of loose gray sand. The area was originally covered with a wonderful forest of long-leaf pine. A characteristic growth is wire-grass, *Aristida stricta,* a long and round-bladed, stiff grass, growing in tufts, six to eight inches high.

Streams are much more numerous than in the Dougherty Plain and the coastal flats. The Altamaha, Ocmulgee, and Oconee rivers have cut valleys 100 to 150 feet below the upland, and have made precipitous bluffs in a few places, but with these exceptions the valleys are shallow and those of the small streams may be described as dish-shaped, or as having low breast-like slopes. The creeks are generally sluggish and flow through broad, swampy bottoms and

[1]Loughridge, R. H., Tenth Census, Vol. VI, Georgia, pp. 15 and 49.
Dall, W. H., U. S. Geol. Survey, Bull. 84, p. 81.
Harper, R. M., Phytogeographical Sketch of the Altamaha Grit Region of Georgia: Annals N. Y. Acad. Sci., Vol. XVII, pt. I, 1906.
McCallie, S. W., Underground Waters of Georgia: Ga. Geol. Survey, Bull. 15, pp. 31-32.
Veatch, Otto, Altamaha Formation of the Coastal Plain of Georgia: Sci., Vol. XXVII, 1908, pp. 71-74.

A. PYLES MARSH, 11 MILES NORTHWEST OF BRUNSWICK, SHOWING TIMBER KILLED BY THE ENCROACHMENT OF SALT WATER UPON THE LAND. OLD STUMPS IN THE FOREGROUND.

B. CHANNEL OF LITTLE OCMULGEE RIVER ONE MILE EAST OF McRAE, TELFAIR COUNTY.

are characterized by "clear" water, or water free from sediment, in contrast to the muddy water of the Ocmulgee, Oconee, and Altamaha. Many of the creeks and branches have their sources in flat, moist, densely wooded areas locally known as "bays," a name probably suggested by the dense growth of bay trees in these areas. The name "bay" is generally applied to upland, flat, swampy tracts in which water stands, due to imperfect drainage and dense vegetation which conserves the rainfall. These areas are really swamps but are not alluvial in character. Cluffs Bay, about seven miles west of Waycross (see map opposite page 44), is an example. The name is also applied to arms of creek and river swamps which form entrants into the dry land and are characterized by a dense growth of bay trees. The bays contain water, but there is no well defined channel of a stream or "run." The water is furnished directly by rainfall and by seepage from the surrounding higher land.

In the southeastern part of the Altamaha upland, the land becomes more level, and finally merges into the moist pine flats of the Okefenokee plain. Throughout this part there are numerous small cypress ponds, and the valleys of the small streams become more swampy, and the streams themselves have banks not more than a foot or two high. The ponds appear to be the result of shallow depressions or slight irregularities left in the land surface after the retreat of the last sea which covered this area. (See page 42.) Along the northern and western edges of this division in Screven, Wilcox, Crisp, Turner, Worth, and Decatur counties, lime-sinks were noted, due to the underground solution most probably of the Chattahoochee limestone formation.

One of the most interesting features of the Altamaha upland is the "sand hills" which border many of the creeks and rivers. These hills slope towards the streams which they border, but may be only very slightly higher, or not at all higher, than the upland back from the stream. They are made up of gray, yellow, or light brown, unconsolidated, structureless quartz sand, which in places reaches a thickness of as much as 30 feet. These sand belts may reach a width of as much as two or three miles, parallel to the streams. It has been observed that the sand ridges are generally on the east or left sides of the streams. The only explanation of this which can be offered, and this explanation is merely tentative, is that the prevailing winds might have caused the westward slopes of the ridges to be the steeper, and that the steep slope governed the direction of the present streams by acting as a barrier. These sand deposits appear to be at higher elevations than the accumulations of loose sand on the first and second Pleistocene terraces of the large rivers. The most prominent

of the sand hills or sand belts are those on the east side of the Ohoopee River, in Tattnall County, near Reidsville; along the east side of the Cannoochee; on the Little Ocmulgee near Helena; along Satilla River from Waycross, westward; and on the east and north side of Pendleton Creek, in Emanuel and Toombs counties. At the foot of these hills are sometimes densely wooded, moist sandbeds known as "hammocks." There are in some places shallow depressions, so-called "sand hill" ponds, in these sand belts, which contain water during rainy periods. The origin of these sands is not yet well understood. They may have been formed during the Pleistocene period, and may be of fluviatile origin; they have doubtless been shifted and in part redeposited by wind.

In comparison with the Dougherty plain, the Altamaha upland has a rolling topography, streams are more numerous, and while there are a few lime-sinks along its borders, it is on the whole in contrast to the level lime-sink tracts of the former region. It is not so entirely featureless as the swampy tracts along the coast and is better drained. In contrast to the Fall Line hills, there is an absence of ruggedness, and the valleys are shallower and in addition there is a notable difference in the flora.[1]

SOUTHERN LIME-SINK REGION

The Southern lime-sink region occupies a small area in the southern part of the State. It embraces the southeastern part of Decatur and the southern halves of Grady, Thomas, Brooks and Lowndes counties and extends into Florida. This division is hilly and is characterized by lime-sinks, lakes, and ponds.

In elevation above sea level, it varies from 150 to 275 feet and the hills rise 50 to 75 feet above the valleys and in a few places as much as 100 feet. The topography is more rugged than that of the adjacent Altamaha upland and the Dougherty plain. This difference and other characteristics of the division are due mainly to the nature of the underlying geological formations. The lime-sinks are due to the underground solution of an upper Oliogocene limestone, the Chattahoochee formation, but this is not the surface formation and is overlain by 50 to 100 feet of sand and clay which is soft and easily eroded, and which probably accounts for the topography being more rugged than that in the western lime-sink region. The lakes and ponds are due to depressions caused by the underground solution of limestone or are lime-sinks which contain water. Some of the lakes are several hundred acres in area and are free from timber growth, but the smaller and shallower ponds support a thick cypress growth. Ocean

[1]Ecological studies in this region have been made by Dr. R. M. Harper. Annals. New York Academy of Sciences, Vol. XVII, No. 1, and other papers.

Pond, in the southern part of Lowndes County, is one of the largest ponds or lakes and has an area of about six square miles. The water-level in these sinks varies with the seasons, and the water has been known suddenly to disappear or to rise, due probably to the opening or stoppage of underground passages.

The drainage, as in the Dougherty plain, is to some extent subterranean and hence, small streams are not numerous. The rivers which flow through the region, the Ocklockonee and Withlacoochee, flow canal-like, through broad sand-covered terrace plains. The water of the streams is not muddy, but is dark on account of dissolved and suspended organic matter, while that of the lakes is clear.

The soil is in many places red, sandy clay, and loam, and the superficial gray sand, characteristic of the Altamaha upland, is not so widely distributed. The tree growth differs somewhat from that of the wire-grass region to the north, in that along with the long-leaf pine there is some oak and hickory.

OKEFENOKEE PLAIN

This division forms a narrow north-south strip 20 to 40 miles wide in the southeastern part of the Coastal Plain, and includes parts of Effingham, Bryan, Liberty, Wayne, Pierce, Camden, Ware, Charlton, Clinch, and Echols counties. On the west this division is approximately marked by a line from the northeast corner of Effingham County, southwestward to near Groveland, Bryan County, thence a few miles south of Glenville, to near Jesup, and Waycross, and is continued in the western boundary of Okefenokee Swamp. There is only a poorly defined escarpment separating this plain from the Altamaha upland and the two merge, but on the east it is separated from a lower coastal terrace by an abrupt descent or escarpment, which will be mentioned later.

The Okefenokee plain is essentially a featureless, sandy flat, in which there are but few streams. It thus presents a contrast to the rolling topography and dendritic drainage of the Altamaha upland. It is dotted with small cypress and gum ponds and swamps, varying from a few acres or a few miles in extent to the immense Okefenokee Swamp. This swamp is one of the most interesting natural features of the Atlantic Coast and will be described later. The region varies in elevation above sea-level from about 60 to perhaps 125 feet and has an eastward slope of about two feet per mile. The drainage is poor, at least 25 per cent. of the area being swampy. There are but few branches and creeks and these flow through broad, swampy flats, only slightly lower than the general level. The striking difference in the number of small streams tributary to Satilla, Altamaha, and Cannoo-

chee rivers in the Altamaha upland and in the Okefenokee plain may be seen by examination of the map of the State. Streams have in only a few places bluffs as much as 30 or 40 feet high. The flatness of the plain and its swampy condition are due both to the newness of the land surface, since the retreat of the sea took place at a comparatively recent geological time, together with the low altitude and the fact that the surface has a heavy covering of loose, porous sand, which absorbs the rainfall and hence lessens surface erosion. The streams are sluggish and with the exception of the Altamaha and Savannah, the water in them is black or coffee color from organic matter. This region is characterized by moist, long-leaf pine and saw-palmetto flats, cypress ponds, gallberry flats, and a thick growth of gums and bays in swamps.

The facts in favor of considering this plain a wave-built, marine terrace, recently raised above sea level, rather than a plain of alluviation or a plain of denudation by stream erosion are: the trend of the plain parallel to the coast and its parallelism to a lower and younger plain, (the Satilla coastal lowland or Satilla plain) which is surfaced with undisturbed beach sand and muds containing shells and other evidence of near coast deposition; this lower plain is separated from the higher plain by an escarpment which doubtless represents former coast bluffs and there is a poorly defined escarpment on the west of the Okefenokee plain which is more or less parallel to the lower escarpment. The Okefenokee plain is covered with a uniform or homogenous deposit of white incoherent sand, which is uncharacteristic of a fluviatile deposit in its structure and composition. There is no well developed drainage system and there are large undrained areas and swamps, which are most plausibly explained as being due to original, inequalities in the land surface.

SATILLA COASTAL LOWLAND OR SATILLA PLAIN

This division is a low marine terrace plain bordering the Atlantic Ocean. It is 20 to 35 miles wide and includes parts or all of the counties of Chatham, Bryan, Liberty, McIntosh, Glynn, and Camden. (See map on page 28.) The western edge of the plain is marked by a rise or escarpment 20 to 40 feet high, which is prominent at Walthourville, Mount Pleasant, and Waynesville, and a short distance east of Folkston. This escarpment may mark a Pleistocene shore line.

The greater part of the plain is 15 to 25 feet above sea level, but there are a few places which reach an elevation of about 40 feet. The

plain has a slight eastward slope, somewhat difficult to estimate, but probably not more than a foot to the mile. Although it is a low, flat, poorly drained plain, it presents several different topographic aspects. It differs from the Okefenokee plain chiefly in its lower altitude, greater area of swamp and inundated land, and in topographic forms incident to low coast land.

The western part is on the whole a sandy flat plain containing an open growth of long-leaf pine. Originally, in the spring and summer, grass and flowers were luxuriant in open areas, termed meadows or "savannas."[1] This plain is dotted with small cypress ponds and also contains large swamp areas, in this respect resembling the higher Okefenokee plain.

The coast line presents a different aspect. Düe to recent submergence, the coast line is irregular and a network of sea-islands, tidal rivers, sounds, estuaries, and marshes have been formed. The land terminates as beach on the sea-islands, and in low sand bluffs, not more than 10 or 15 feet above low tide, and as marshes at the mouths of the rivers flowing into the ocean. The islands are sand-covered, and some of them exhibit sand dunes, but the dunes nowhere reach great magnitude. The islands form in the aggregate an area of perhaps 500 to 600 square miles. The largest are Cumberland, Jekyl, St. Simon, Sapelo, St. Catherine, Skidaway, and Tybee. They are of considerable historical interest and some of them are noted as resorts.

The tree growth of the coast land is characterized by the cabbage palmetto and live oaks, which are more abundant than farther west.

There are two classes of swamp land, the upland swamp and the tidal swamp. The first is represented by such swamps as Buffalo Swamp in the western part of Glynn County which probably represent the sites of former shallow sounds or coastal lagoons and marshes which have become land surface through uplift and the retreat of the sea approximately to its present position. After this movement, however, there was again a subsidence of the coast as is indicated by drowned river courses. This subsidence

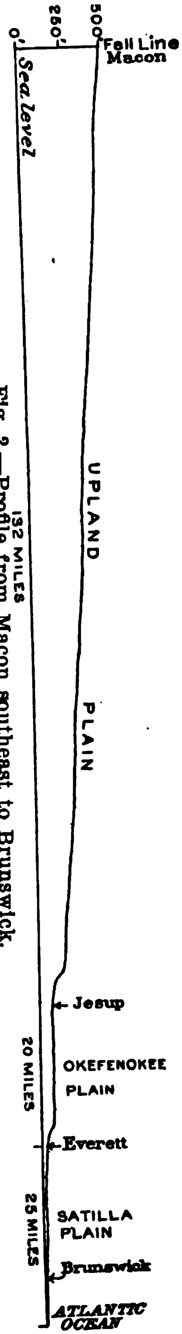

Fig. 2.—Profile from Macon southeast to Brunswick.

[1]An excellent description is given by R. H. Loughridge, Tenth Census, Vol. 6, Cotton Production, Georgia, p. 51.

seems to be going on at present, causing the sea slowly to encroach on the land. The best proof of this is the presence of tree stumps and even dead standing trees in brackish water marshes. (See plate I, A, opposite page 32.)

Considerable areas of "tide swamp" occurs along the Savannah, Ogeechee, Altamaha, Satilla, and St. Marys rivers. This lowland bordering the rivers is partly submerged at high tide, and differs from the marsh land chiefly in that it is covered by fresh water and not salt as in the case of the marsh. Tide swamp extends up the above named rivers 10 to 20 miles above the salt marsh, and was at one time utilized in rice-growing and is still so used to a small extent.

The salt marsh reaches its greatest extent at the mouths of the rivers, but probably does not aggregate more than 150 or 200 square miles.[1] The marsh land is probably due in the main to submergence of the coast, although the silting up of water areas, by sediment carried down by streams, has also doubtless been a factor.

The plain is poorly drained and there are but few streams owing to the newness of the land surface and its low altitude. The streams are sluggish, and are so-called "clear water streams," except the Savannah and the Altamaha, the waters of which are yellow from suspended sediment. The waters of the other streams, however, are dark or even black from organic matter. The slight eastward slope of the plain has caused the streams to flow directly east to the ocean. An interesting effect of the slight eastward slope of this and the higher Okefenokee plain is observed in the case of the Satilla and Little Satilla rivers in Camden County. The Satilla has no tributaries at all entering from the east, and the head branches of the Little Satilla are extended to within one and one-half miles of the Satilla near Atkinson.

Recent submergence has caused a *drowning* of the streams and in consequence the mouths of the large rivers have been converted into estuaries and rendered navigable by sea-going vessels from 10 to 20 miles from the coast, and small streams which, so far as their lengths are concerned, are really no more than branches or creeks, have been enlarged and are styled rivers. In this latter class are such streams as Crooked River, Turtle River, and Sapelo River. There is also a network of serpentine water-ways on the sea islands which are termed rivers and creeks, but are really no more than natural tidal canals.

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[1]No survey of the marsh land of the State has yet been made, and hence accurate figures can not be given.

TERRACES

The terraces constitute an interesting physiographic subject in the study of the Coastal Plain. They are intimately connected with the Pleistocene geology and the subject demands further study with the aid of detailed topographic maps, before final conclusions can be offered.

Two[1] broad terrace plains parallel to the coast are easily recognized, while the large rivers are bordered by fluviatile terraces believed to be equivalent in age to the two coastal terrace plains. The terraces are illustrated in fig. 2 and Pl. II. The older is designated the Okefenokee plain, and the younger the Satilla plain. For the area of these plains see map on page 4.

The river terraces are best developed in the upper part of the Coastal Plain along Chattahoochee, Ocmulgee, and Savannah rivers, and are conspicuous at Columbus, Macon, and Augusta. The lower or younger terrace, also known as "second bottoms," lies 15 to 50 feet above the rivers, and is a smooth plain, varying roughly from one-half to three or four miles in width. The second terrace lies 50 to 100 feet above the rivers; it is in this plain that the lower has been cut, and it has been modified to a greater extent by erosion. The upland plain bordering the rivers is from 125 to 250 or 300 feet above river levels. The terraces will receive further mention in the chapters on Pleistocene geology.

DRAINAGE OF THE COASTAL PLAIN

The drainage of the Coastal Plain discharges into the Atlantic Ocean and the Gulf of Mexico. The drainage basins, according to a map by B. M. Hall,[2] are: (1) Savannah Basin; (2) Ogeechee Basin; (3) Altamaha Basin; (4) Satilla and St. Marys Basin; (5) Suwanee Basin; (6) Ocklockonee Basin; (7) Apalachicola Basin, drained by the Chattahoochee and the Flint. The first four dis-

[1] It is not improbable that a third higher terrace plain exists, but sufficient proof of its existence has not been obtained to warrant positive statements.

[2] Water Powers of Georgia. Geol. Survey Ga., Bull. No. 3-A. p. 16.

charge into the Atlantic and form considerably the larger drainage area; the remaining three discharge into the Gulf of Mexico.

The rivers of the Coastal Plain fall naturally into two simple classes: (1) those originating in the Piedmont Plain and Appalachian Mountains and thence traversing the Coastal Plain; (2) native streams or those having their source within the Coastal plain. To the first class belong Chattahoochee, Flint, Ocmulgee, Oconee, Altamaha, Savannah, and Ogeechee rivers, although the last throughout the greater part of its course has the aspect of a stream of the second class. The rivers of the second class are much more numerous, and the principal ones are the Little Ocmulgee, Ohoopee, Cannoochee, Satilla, St. Marys Suwanee, Allapaha, Withlacoochee, and Ocklockonee.

The rivers of the first class have greater drainage areas, carry a greater volume of water, have greater lengths, and have cut deeper and wider valleys. The water of these rivers is always muddy, except that of the Ogeechee, whereas the water of the streams of the second class are clear, and this fact furnishes a popular distinction—"clear water"[1] and "muddy water" streams. Especially the Ocmulgee, Oconee, Altamaha, and Savannah are bordered by broad lowlands or swamps, in which a large part of the sediment is clay, while the smaller Coastal Plain rivers of the second class have sandy banks and the low terraces bordering them are composed almost entirely of sand. The explanation is that in the one case a large amount of sediment is derived from the red clay hills of the Piedmont Plain; while in the other the streams flow through geological formations that are predominantly sand, a region where erosion is not active, many of the smaller streams having not even cut through the superficial sands.

The rivers across the Coastal Plain probably assumed their courses on a comparatively level plain, following the retreat of the sea from the land, and extended their courses across the new land surface, so that, for example, the age of the Ocmulgee at the Fall Line is much greater than the lower 20 or 30 miles of the Altamaha or that part which flows across the later Pleistocene plain. The directions of the streams are due to the initial slope of the new land surface upon which they started their courses. Thus all of the rivers have general south, southeast and east courses, since the tilting of the land surfaces has been in these directions. The rivers have not in all cases formed straight courses to the coast on account of the interposition of certain

[1]While the native streams of the Coastal Plain are termed "clear," the water is clear only in that it is comparatively free from suspended silt and clay. The water does not possess the transparency of clear mountain streams, but is pale brownish or even black from organic matter held in solution and suspension. The water of Suwanee and St. Marys rivers, near their source, the Okefenokee Swamp, is of almost inky blackness.

A. TERRACE AND ESCARPMENT BORDERING ST. MARYS RIVER (FLORIDA SIDE) OPPOSITE TRADERS HILL, CHARLTON COUNTY, GA.

B. SATILLA TERRACE PLAIN IMMEDIATELY WEST OF NEW SAVANNAH BLUFF, SAVANNAH RIVER, RICHMOND COUNTY.

topographic and geologic factors. The direction of a stream might have been deflected by slight irregularities in the new land surface or upraised sea-floor, or by certain geological conditions, which it encountered in cutting down its course.

The St. Marys and Satilla rivers present a curious anomaly in the courses they have taken to reach the sea. (See map opposite page 44.) The St. Marys issues from the southern end of Okefenokee Swamp, flows south for about 15 miles, thence east for about eight miles, thence makes a right-angle turn and flows north for a distance of over 30 miles and to within four miles of the Satilla, thence flows to the Atlantic in a course slightly south of east. The Satilla has its source in the Altamaha upland and flows eastward as far as Atkinson in Wayne County, then instead of taking the most direct course to the ocean, which would be the course of the Little Satilla, it flows south for more than 20 miles, thence makes an abrupt turn and flows east to the Atlantic. These rivers are young, dating probably from the Pleistocene, and are flowing across a newly formed land surface. Their peculiar courses are probably due to the original uneven surface of the upraised sea-floor, caused by low sand ridges or sand heaps such as are incidental to beaches and very shallow seas bordering a low sandy coast-land. The most direct course to the ocean, and the one in conformity with the general slope of the land, which the St. Marys might have taken, is through St. Johns River, Florida, but it was probably deflected to the north by a low sand ridge. There is also a sand ridge separating the St. Marys and the Satilla, which probably prevented their junction.

The almost direct south courses of the Allapaha, Withlacoochee, Little, and Ocklockonee rivers are probably due to a low, southward-dipping and flat topped arch in the upper Oligocene strata. A similar flexure probably exists along the Chattahoochee, as is indicated by the unequal drainage divide between the Flint and the Chattahoochee, the great depth to which the latter river has cut its valley, its trench-like channel and the absence of flood plain swamp, in contrast to the other large rivers.

The general southeastward and eastward courses of the Satilla, Altamaha, Ogeechee, Savannah and other streams in the eastern half of the Coastal Plain, is in consequence of the initial tilt of the land surface on which they originated. The explanation of the general insignificance and shortness of northward and westward flowing tributary streams is hence obvious.

LAKES AND PONDS

The lakes and ponds of the Coastal Plain are of three types: (1) those due to lime-sinks; (2) those caused by original shallow depres-

sions in the land surfaces after the retreat of the sea; (3) river flood-plain lakes.

Lime-sink lakes and ponds are confined mainly to the western and southwestern parts of the Coastal Plain, to the areas described above as Dougherty plain and Southern lime-sink region, but there are also lime-sinks and small ponds in Screven County, in the southern parts of Burke, Jefferson, and Washington counties, and along the western edge of the Altamaha upland. The depressions which lakes and ponds of this type occupy are the result of underground solution of limestone with the formation of subterranean caverns, the roofs of which become weakened and fall in, causing depressions at the surface. The process by which they were formed is in operation at the present time, and sinks have formed since the settlement of these regions. They vary in size from ponds from 100 to 200 feet in diameter to lakes of an area of as much as six square miles. The shallow ponds often become dry and the water level in the larger and deeper ponds varies considerably with the seasons. Some attain considerable depth, and are connected by open passages with underground channels, an example of which is the Lime-sink, Forest Falls, eight miles north of Whigham, Grady County. A small stream flows into this sink, which is about 90 feet deep, and disappears through an opening in the bottom.

The most notable of the larger lakes are Ocean Pond and Long Pond in Lowndes County, Original Pond, three miles west of Metcalf, and Rock Pond, near Camilla, Mitchell County.

The second class represent depressions in level sandy plains. These are usually shallow ponds of small area and most of them contain a growth of cypress and gum. They are dependent upon seepage and become dry, with a few exceptions, in times of severe drought. They are numerous in the southeastern part of the Altamaha upland, are typically developed on the Okefenokee plain, and also appear on the Satilla marine terrace plain 20 to 40 feet above sea level. It is probable that these ponds for the most part occupy shallow depressions which were present on the plains when they were first uplifted and became land surface, there, as yet, not having been sufficient subaerial erosion to efface them.

There are also a number of untimbered expanses of water in the Okefenokee Swamp which are termed "lakes." (See map opposite page 44.)

The third class represent abandoned channels of rivers and occur in river flood-plains. This is the type of lake so extensively developed along the lower course of the Mississippi. They are in the form of ox-bows, or are elongated, rarely circular; their water is usually

affected by high water or overflow of the rivers along which they occur and is less clear than that of the lime-sink lakes and ponds. They may be connected with the river or their mouths may be silted up entirely, depending upon how recently they have been formed, but they are all subject to overflow during flood stages of the rivers. Hershman Lake in Screven County and Black Lake in Wilkinson County are the best examples of this type. Other lakes occur along the lower courses of the Oconee and Altamaha.

FLUVIATILE AND UPLAND SWAMPS

The fresh water swamps of considerable areas are of two types: fluviatile swamps and upland plain swamps. The latter appear along the coastal belt and owe their existence to the flatness and consequent imperfect drainage of the land surface. They are *upland* in that they lie at a higher level than the river swamps, and also in comparison with the river tide-swamp and the salt marshes although they may not be more than 20 feet above sea level. Okefenokee Swamp is a large upland swamp.

Nearly all of the streams of the Coastal Plain, even the small branches, are bordered by swamps. The most extensive are those bordering the large rivers of the first class. The swamp land lies only a few feet above the rivers and the frequent overflows maintain it in a swampy condition. Along the lower part of Savannah River the swamp reaches a width of five or six miles; it is densely wooded with a growth of oak, ash, cypress, gum, and pine. There are also broad swamp areas along the Ogeechee, Altamaha, Oconee, Ocmulgee, and upper part of the Flint; the Chattahoochee forms an exception since there is scarcely any land along its course in Georgia which could be termed swamp.

The small branches, creeks, and rivers flow through broad, densely wooded lowlands, very often spreading out through the trees until it is difficult to determine just where the channel proper is located, and in places necessitating low bridges or a succession of bridges one-fourth to one mile in length to effect a safe road crossing. Swamps of such character are notable along Ogeechee River, Williamson's Swamp Creek, in Jefferson County; Commissioner's Creek, in Wilkinson County; and along the head waters of Little and Allapaha rivers in Tift, Irwin, and Berrien counties.

The amount of fluviatile or river and creek flood-plain swamp amounts to perhaps 1,000 square miles[1] in the Georgia Coastal Plain.

[1]No complete survey of the swamp land of Georgia has been made, and the figures are only a rough estimate based on a knowledge of the approximate widths of the swamp along the largest rivers and creeks.

This land lies generally form two to eight feet above mean stages of water.

THE OKEFENOKEE SWAMP.

The Okefenokee Swamp is perhaps the greatest natural wonder in the State. It lies in the southeastern part of the Coastal Plain, embraces parts of Ware, Charlton, and Clinch counties, and extends to the Florida line. It has a length of about 40 miles, a width of 30 miles, and an area of between 700 and 800 square miles. The swamp has been fully explored by hunters and lumbermen, but no very extended descriptions of it have been published. The following excellent short description is that of Dr. R. H. Loughridge,[1] who was one of a party that made a partial survey of the swamp in 1875:

> This swamp (Okefenokee) has a width of 30 and a length of 40 miles, covering an area of about 500,000 acres. It is in reality an *upland swamp*, having an altitude of 120 feet above tide-water on St. Mary's River. A sand ridge (part of the water divide of the State) 30 feet above the swamp extends along its eastern border to the South, becoming lower as it reaches the southern horseshoe bend of St. Mary's River. The swamp is highest on the northeast, and falls irregularly to the south and southwest from 126½ to 111½ feet at Ellicott's mound and on the southwestern corner.
>
> The eastern part, 12 miles in width, is an open "prairie" or marsh, largely covered with water, in which are long rushes and water-lillies. Under its surface is a dense body of moss from four to six feet thick, the great mass of which is decayed, forming muck and peat. It is so dense that it will readily bear up a man's weight, merely sinking a little and rising for many feet around; hence the name of Okefenokee—"trembling earth." Small islands, covered with clumps of cypress, bay, and cassino, frequently occur. The western part of the swamp is mostly covered by cypress trees and a dense growth similar to that of the small swamps outside, so tied together by bamboo briers and vines as to be impenetrable except by slow and terious cutting away with bush knives. Small open marshes, and also a number of large islands, are found throughout this region. These islands are quite level, but are slightly elevated above the swamp lands, and have a sandy soil, with an open timber growth of long-leaf pine and a very low undergrowth of saw-palmetto, and are similar in every respect to the mainland. Their dimensions are three or four miles by from one to two, and they are bordered by a low hammock land, on which there is a growth of magnolia, oak, etc. Hunters find deer and bear on these islands. The soil or bottom of the swamp proper seems to be but little else than white sand.

Dr. R. M. Harper[2] has lately published a description in which the literature and history of exploration is summarized, the geography, vegetation, etc., of the swamp are briefly set forth, and illustrations from several photographs taken in the swamp are given.

Such a phenomenon as the Okefenokee Swamp can not be passed over without offering some explanation of its existence. The following relating to its origin is quoted from Dr. Harper's paper:

> Immediately east of the Okefinokee is one of the most interesting topographic features of the region, which would scarcely be noticeable but for the

[1] Tenth Census, Vol. VI, Cotton Production of Georgia, p. 51.

[2] Pop. Sci. Monthly, June, 1909.

general flatness of the country. It is a broad low ridge, exactly parallel with the coast and just about forty miles distant from it. This ridge has been traced by the writer from a few miles west of Jesup southward into the great bend of the St. Mary's River, and about thirty miles into Florida, where it is known as the "Trail Ridge," and happens to coincide in part with the Atlantic and Gulf divide and with the eastern boundary of Baker and Bradford Counties, though still maintaining its parellelism with the Atlantic coast. It is not an important divide in Georgia, though no streams intersect it between the St. Mary's and the Altamaha except the Satilla and Little Satilla Rivers.

At Camp Cornelia, where the old drainage ditch of the Suwanee Canal Company cuts through it, this remarkable ridge is about two miles wide and only about forty feet high; and it probably keeps practically the same dimension for many miles north and south. Its slopes are so gentle as to be scarcely noticeable to a person passing over it, but when viewed from a point a few miles away on one of the straight railroads which cross it, it stands out quite conspicuous.

"Trail Ridge, or Okefinokee Ridge, as the Georgia end of it might be called, does not belong to the class of *cuestas* or inland-facing escarpments which can be seen in many places in the upper half of the coastal plain, for it slopes equally on both sides and has no stream hugging its inland edge as far as known. Moreover it is too smooth and too straight to have been formed by erosion. The same reasonable explanation of it would seem to be that it marks a comparatively recent slight flexure of the earth's crust, formed during one of the oscillations which the coastal plain experienced several times during its making. There seems to be a similar though smaller ridge about fifteen miles east of it, but so little is known about that that it could not be mapped at the present time. Mount Pleasant and Waynesville, near the boundary between Wayne and Glynn counties, are located on the latter ridge and along its summit was one of the principal roads from Savannah to East Florida a century ago, followed by Bartram and other travelers.

The internal structure of the Okefinokee Ridge is not its least interesting feature. In the big ditch at Camp Cornelia, as well as at the crossings of four railroads (three of them shown on the map and one a little farther north), there occurs beneath a few feet of white sand a chocolate-colored or almost black material of unknown depth known locally as "hardpan." No analysis of the hardpan is available, but when pulverized in the fingers it feels like nothing but sand. Its dark color is doubtless due to vegetable matter, with a little cement of iron oxide or bog iron ore, which makes it so hard in the mass that dynamite was used in removing it, it is said. No recognizable organic remains were noticed in it, but a faint horizontal stratification could be detected. The aspect of the hardpan is so similar to that of the subsoil of existing salt marshes that its origin is not hard to guess.

Although this peculiar formation may not be confined to the Okefinokee Ridge, its extent is evidently limited; for in railroad cuts around Waycross and Folkston and in Camden county and elsewhere the ordinary reddish Pliocene loam can be seen near the surface, without any signs of the black hardpan. The hardpan was doubtless formed in some prehistoric swamp or marsh occupying a somewhat larger area than Okefinokee does now—perhaps the Suwanee Straight of geologists, which is supposed to have separated Florida from the mainland in Miocene times. It seems to have no effect on the vegetation above it, which is just like that of the ordinary flat pine-barrens underlaid by the loam.

Assuming the foregoing theories to be true we can now trace the probable development of Okefinokee Swamp. When the ridge was thrown up across the shallow trough which had been Suwanee Strait it naturally created a basin behind it, which must have quickly filled with water, forming a large, shallow lake. This lake then began to fill with vegetation, as many other

shallow lakes then began in temperate regions are doing, and gradually took on the aspect it has to-day, which will be described more in detail below, under the head of vegetation. A glance at the map will show how the waters are damed up by the ridge, the straight eastern border contrasting with the very irregular western border of the swamp.

The notes of the writer on the geology of the region and its physiographic history differ somewhat from the views advanced in the preceding quotation. It is believed that the swamp lies upon a terrace plain, of probable marine origin, parallel to a lower terrace plain, which lies from 15 to 40 feet above sea-level, and extends to the present coast. The western edge of the lower plain is marked by an escarpment which is prominent at Waynesville, Mt. Pleasant, Walthourville, and a few miles east of Folkston, and probably represents the shore-line of the latest Pleistocene sea. The next higher plain, the Okefenokee Plain, extends parallel to the lower, and from the above mentioned escarpment extends 20 to 40 miles westward. The western extent of the plain is not distinctly marked (although a good topographic map would probably reveal it), but it is believed that it is a line approximately from Clyo in Effingham County, southwestward to near Groveland, thence to Jesup, Offerman, and Waycross and thence follows the northern and western borders of Okefenokee Swamp. There is a low sand ridge on the east side of the swamp, which has acted, to some extent, as a dam to the drainage from the west.

The swamp does not occupy a single large depression or basin, since elevations show that the northern edge is 15 feet higher than the southeastern corner, and there are also differences of elevation of the surface within the swamp. The swamp conforms, in general to the southeastward tilt of the plain upon which it is located. The land now occupied by the swamp was so flat, that the rainfall was not readily removed and hence accumulated as broad sheets of water, which vegetation converted into swamps. The presence of islands in the swamp which are reported to be very similar in soil and tree growth to the dry land adjacent, together with the fact that creek runways still exist within the swamp, is very suggestive that the swamp area did not differ materially from the land to the north and west and that the Okefenokee was formed by the gradual accumulation of water and consequent aquatic vegetation. The "bays" or entrants of swamp into the dry land, along the courses of tributary creeks, have produced the ragged

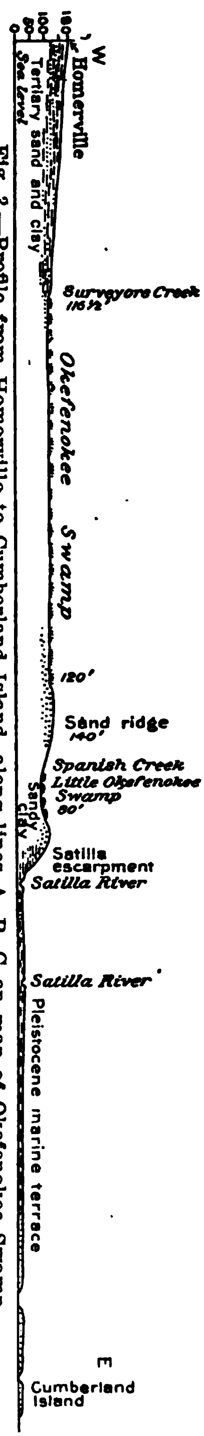


Fig. 3.—Profile from Homerville to Cumberland Island, along lines A, B, C, on map of Okefenokee Swamp.

or irregular north and west boundaries and indicate the process by which the swamp has increased in area, namely by the enlargement and union of creek swamps and final obliteration of the stream channels. Should there be a period of a number of years with the precipitation even slightly above the present normal the whole area northwest of the swamp to the Atlantic Coast Line Railroad and beyond would be incorporated as a part of the Okefenokee. This area is at present formed of flat, ill-drained islands surrounded by narrow strips of swamp.

The swamp then owes its existence to the general flatness of the original land surface which has been lifted above sea level without deformation. The sand ridge on the east, although acting as a dam for a part of the drainage, was a subordinate agent in producing the swamp, as is in a measure proved by the absence of any conspicuous ridge or barriers on the south and southeast, and especially by the differences in elevations of various parts of the surface of the swamp. As for example, the elevation at the point where Cypress Creek issues on the western side is 111½ feet, while at a point half way between this and St. Marys River the elevation is 118½ feet, and the point where the St. Marys issues on the southeastern corner is 111½ feet. If the existence of the swamp depended entirely upon the barrier ridge on the east the level of the western margin of the swamp should be higher than the intermediate levels between the western and eastern margins. This is not true according to known elevations.

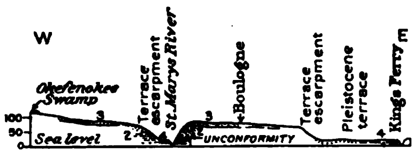


Fig. 4.—Profile from Okefenokee Swamp to Kings Ferry, Florida, along line D—E, on map of Okefenokee Swamp.

The geologic formations adjacent to the swamp are late Tertiary, Pleistocence, and Recent. The Alum Bluff formation (upper Oligocene) consisting of greenish, sandy clays, and overlain by a small thickness of Altamaha (Lafayette?) and surficial sand, occurs to the north and west, and very probably underlies the swamp. As inferred from the record of a well at Waycross, it is about 300 feet in depth to a limestone formation.

The Altamaha (Lafayette?) formation is typically exposed in cuts and excavations near Waycross, and probably also occurs east of the swamp. This formation is composed of red, argillaceous sand and sandy clay. To the east of the swamp the plain is covered by gray

and yellowish or brownish, incoherent quartz sand, varying from two or three to 15 or 20 feet in thickness. This sand forms the sand ridge on the east side of the swamp. It is considered a Pleistocene deposit. Beneath the surficial sand there is a small thickness, not exceeding 40 or 50 feet, of red, argillaceous sand and bluish clay, Pliocene or Pleistocene in age. Fossiliferous beds of white, argillaceous limestone and greenish or drab laminated clay, probably Pliocene or Pleistocene, and older than the surficial sand, occur in the banks of St. Marys and Satilla rivers a few feet above sea level.

So far as known, the deposits in the swamp are white sand and recent vegetable or semi-peaty accumulations. White or gray sand occurs on the edges of the swamp and only sand is exposed in the old drainage ditch constructed by the Suwanee Canal Company, near Trader's Hill. Fishermen and hunters report white sand in the bottoms of some of the lakes. Peaty accumulations three or four feet thick are reported, and these organic accumulations are known to have been fired from nearby forest fires during periods of drought.

There is no evidence in the many exposures of strata examined in Charlton, Ware and Camden counties, that any considerable flexures or folds exist in this part of the State. The escarpment a few miles east of the swamp, which suggests the limb of an anticlinal fold, is believed to be a Pleistocene erosion feature, as stated above.

TABLE OF GEOLOGIC FORMATIONS NEAR OKEFENOKEE SWAMP

Recent:
- Peaty muck in the Okefenokee Swamp.

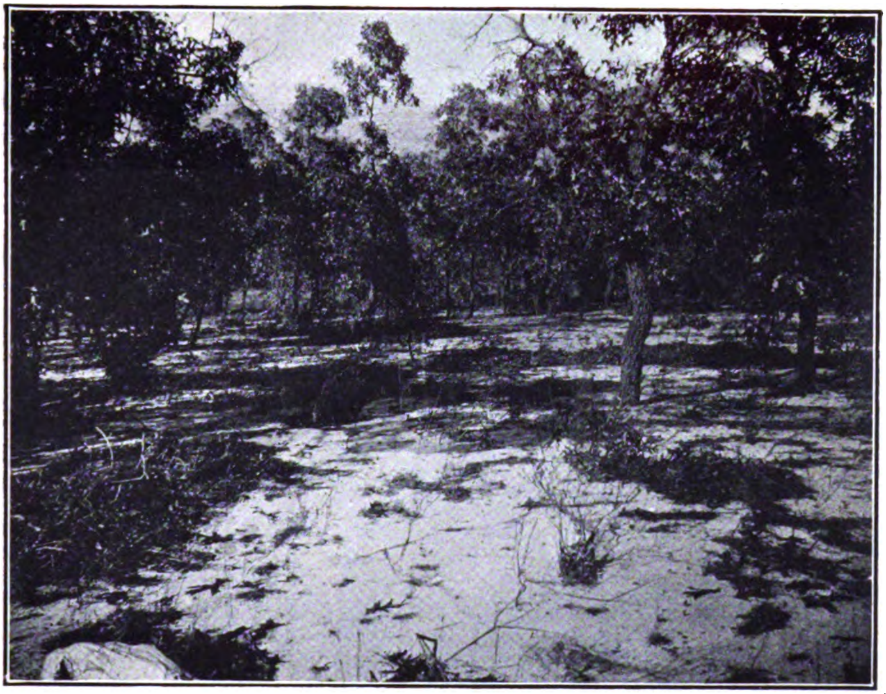
Pleistocene and Pliocene (?)
- Satilla formation—clay terraces or flatwoods bordering St. Marys and Satilla rivers.
- Okefenokee formation—surficial white sand, and perhaps some red sand and mud, the latter occupying the sites of ancient estuaries or shallow bays.
- Altamaha (Lafayette ?)—red, argillaceous sand, typically developed at Waycross.
- Charlton formation—fossiliferous limestone and clay on St. Marys River.

Miocene.
- Probable occurrence at Owens Ferry, Satilla River.
- Miocene strata are also known[1] near Jacksonville, Fla.

Oligocene (Alum Bluff).
- Sandy, greenish, and drab clays of the Alum Bluff formation, overlain by a small thickness of Altamaha (Lafayette ?) and surficial sand, occur on the north and west sides of the swamp.

There are numbers of smaller swampy areas in the Okefenokee Plain. Some of these are merely broad, undrained flats, due, perhaps, to original inequalities in the land surface and are Okefenokees

[1]Matson and Clapp. Fla. Geol. Survey, Second Annual Report, 1909. p. 108.



A. SAND HILL ON EAST SIDE OF LITTLE OCMULGEE RIVER, TWO MILES NORTHEAST OF HELENA, TELFAIR COUNTY.

B. A LIME SINK POND KNOWN AS WAVING POND, SEVEN MILES NORTHWEST OF SYLVESTER, WORTH COUNTY.

on a small scale. The general slope of the plain eastward is perhaps not more than two feet per mile, and poor natural drainage is readily inferred.

OTHER SWAMPS

There are also swamp areas in the lower coastal terrace plain which lie 15 to 25 feet above sea level. These have the appearance of being the sites of ancient lagoons or shallow sounds. Buffalo Swamp in the western part of Glynn County is an example. This swamp extends from Altamaha River southward to Turtle River and has a much greater length than width. It contains clay and is slightly lower than the sandy pine and palmetto land on both sides. Oyster shells in the clay bear evidence of its marine origin. Cabbage palmetto trees occur near Bladen and Everett, and are possibly a survival from the period when this area was a sound or marsh. It is often entirely covered with water during the rainy seasons but becomes almost dry in times of drought. Should the present coast be elevated 20 or 30 feet the waterways and marsh between St. Simon Island and the mainland would probably be the site of such a swamp area as Buffalo Swamp.

The Big Pond, located seven miles north of Baxley, Appling County, is worthy of special mention here. Although this tract is locally termed "pond," it is a misnomer, as it is more properly a swamp. The only open water is a small lake in the interior, reported to be not more than 100 yards long, whereas in the area as a whole there is a thick growth of cypress, gum, and pine, with an undergrowth of small trees and bushes. (See plate IV, A.) Big Pond lies upon a flat, sandy, pine-covered plain, at an elevation about 200 feet above sea level. It has an area, including a small swamp, known as "Second Pond," of about eight square miles. The two "ponds" are connected by a narrow swamp known as Tiger Bay. On the east side of the swamps there is a low ridge covered with superficial gray sand that reaches a thickness of about 10 feet. Ten-Mile Creek, a small tributary of Altamaha River, flows sluggishly from the southern end of Big Pond.

Big Pond belongs to the upland, non-alluvial class of swamps, and is probably somewhat similar in origin to Okefenokee Swamp and to the smaller cypress and gum ponds which are so numerous in the southeastern part of the Coastal Plain.

SPRINGS

There are a few large springs of physiographic and geologic interest. These springs are in limestone areas and, as they appear to

be connected with subterranean streams, many of them may be described as natural artesian wells. The water is clear and very transparent, usually has a deceptive, faint bluish color, is but little affected by rains, and evidently comes from great depths. The largest of these springs is Blue Spring, four miles south of Albany. The water at this place rises under considerable pressure through a roughly circular opening in limestone, and has an enormous flow.[1] Similar springs are: Blue or Wade Spring, seven miles east of Quitman; McIntyre Spring on the Withlacoochee near the Florida line; Blue or Russell Spring of Decatur County; Well, Wilkes, and Rock springs of Laurens County, and Magnolia Spring of Jenkins County. These are all large springs rising through limestone caverns.

Small, both permanent and intermittent springs, of only minor importance, are numerous except along the coastal lowlands.

ELEVATIONS

BY OTTO VEATCH

In the general absence of topographic maps, giving accurate elevations in the Coastal Plain, it is believed that the compilations here given will be of interest and of practical value in working out geologic problems and in the study of underground waters.

The following list of elevations has been compiled chiefly from: Dictionary of Altitudes in the United States, by Henry Gannett, Bulletin No. 274 of the U. S. Geological Survey; from the list of elevations given in the report on the Water Powers of Georgia, Bulletin No. 3-A of the Geological Survey of Georgia; from the reports of the U. S. Army Engineers on the surveys of Ocmulgee, Oconee, Altamaha, and Savannah rivers; and from the Columbus, Talbotton, and Milledgeville topographic sheets of the U. S. Geological Survey. Several of the elevations given are merely rough estimates or guesses based on other elevations and upon knowledge of the topography by the author, in a few instances supported by aneroid barometer readings. In some of the figures given in this compilation there may be errors of even several feet, but, notwithstanding, these elevations are better than none at all, and the errors are not so great but that the data may be useful in the study of physiography, geology, and artesian waters.

[1]Discharge measurements by B. M. and M. R. Hall (U. S. Geological Survey, Water Supply and Irrigation Paper, No. 197, page 236) varied from 26.4 second-feet to 135 second-feet. This is approximately 18,000,000 to 87,000,000 gallons per 24 hours. This is the largest spring in the State.

The abbreviations used are:
A. B. & A.—Atlanta, Birmingham & Atlantic Railroad.
A. C. L.—Atlantic Coast Line Railroad.
C. of Ga.—Central of Georgia Railway.
Ga. R R.—Georgia Railroad.
G. S. & F.—Georgia Southern & Florida Railway.
L. & N.—Louisville & Nashville Railroad.
M. D. & S.—Macon, Dublin & Savannah Railroad.
S. A. L.—Seaboard Air Line Railway.
U. S. A. Eng.—United States Army Engineers.
U. S. G. S.—United States Geological Survey.

Abbeville	Rough estimate	225 ?
Abbeville, low water, R. R. bridge	U. S. A. Eng	169.33
Achord	U. S. G. S.	274
Acree, Dougherty County	A. C. L. R. R.	205
Adams Park	U. S. G. S.	259
Adel	G. S. & F. Ry.	246
Adrian, Emanuel County	Rough estimate	290 ?
Albany	C. of Ga. Rwy	184
Albany, Flint River level	A. C. L. R. R	127
Allapaha	A. C. L. R. R	293
Alexanderville	A. C. L. R. R	153
Allentown	M. D. & S. R. R	411 ?
Ambrose, Coffee County	A. B. & A. R. R.	395
Americus	C. of Ga. Rwy	360
Andersonville	C. of Ga. Rwy	394
Arabi	G. S. & F. Ry.	460
Argyle	A. C. L. R. R	161
Armena	S. A. L. Ry.	275 ?
Ashburn	G. S. & F. Ry.	450
Augusta, Union Station	City Engineer	143
Augusta, River gage	Weather Bureau	100
Baconton	A. C. L. R. R	160
Bainbridge	A. C. L. R. R	110
Bainbridge, river level	Rough estimate	80
Bartow	C. of Ga. Rwy	237 ?
Bath, Richmond County	Rough estimate	80
Baxley	U. S. G. S.	206
Belair	Ga. R. R.	295
Berzelia	Ga. R. R.	488
Blackshear	A. C. L. R. R.	106
Bladen	S. A. L. Ry.	22
Blakely	Rough estimate	275
Blakely	Weather Bureau	300
Bloomingdale	C. of Ga. Rwy.	24
Bonaire	G. S. & F. Ry.	354
Boston	A. C. L. R. R.	194
Bostwick (Paschal)	C. of Ga. Rwy.	669
Boulogne, Florida	A. C. L. R. R.	70
Box Springs	U. S. G. S.	364
Braganza	A. C. L. R. R.	144
Brentwood	U. S. G. S.	167
Brewer (Tusculum P. O.)	C. of Ga. Rwy.	118
Brooklyn	S. A. L. Ry.	691

Brinson	A. C. L. R. R.	104
Brunswick	Sou. Rwy.	13
Brunswick (City Hall)	U. S. G. S.	11
Buena Vista	Rough estimate	590
Bullards	U. S. G. S.	259
Burroughs	A. C. L. R. R.	19
Bushnell	A. B. & A. R. R.	385 ?
Butler	C. of Ga. Rwy.	650
Byromville	A. B. & A. R. R.	365 ?
Byron	C. of Ga. Rwy.	515
Cairo	A. C. L. R. R.	237
Camak	Ga. R. R.	578
Cameron	C. of Ga. Rwy.	103
Camilla	A. C. L. R. R.	167
Carrs Station	U. S. G. S.	500
Cecil	G. S. & F. Ry.	250
Chauncey	U. S. G. S.	300
Chula	G. S. & F. Ry.	395
Claxton	S. A. L. Ry.	194 ?
Clifton	C. of Ga. Rwy.	22
Climax	A. C. L. R. R.	277
Clyo	S. A. L. Ry.	74
Cochran	U. S. G. S.	342
Coleman	C. of Ga. Rwy.	391
Coley	Sou. Rwy.	303
Collins	S. A. L. Ry.	238
Colon	G. S. & F. Ry.	137
Columbus, Union Station	C. of Ga. Rwy.	260
Columbus, river level	U. S. G. S.	200
Cordele	G. S. & F. Ry.	336
Crescent	Rough estimate	18
Culverton	Ga. R. R.	549
Cusseta	S. A. L. Ry.	540
Cuthbert	C. of Ga. Rwy.	446
Cutler	G. S. & F. Ry.	78
Cuyler	S. A. L. Ry.	37 ?
Cycloneter	G. S. & F. Ry.	410
Dakota	G. S. & F. Ry.	410
Darien	Rough estimate	15
Dasher	G. S. & F. Ry.	185
Davis	A. C. L. R. R.	238
Davisboro	C. of Ga. Rwy.	302
Dawson	C. of Ga. Rwy.	352
Dearing	Ga. R. R.	464
Devereux	U. S. G. S. B. M.	577
Dewitt	Butt's map	175
Dixie	A. C. L. R. R.	130
Dock Junction	U. S. G. S.	25
Doctortown	A. C. L. R. R.	74
Doctortown, low water level	U. S. A. Eng.	31.72
Donaldsonville	A. C. L. R. R.	139
Douglas	A. B. & A. R. R.	388 ?
Doublerun	A. B. & A. R. R.	363 ?
Dover	C. of Ga. Rwy.	104
Dry Branch	M. D. & S. R. R.	368 ?
Dublin	M. D. & S. R. R.	231[1] ?

[1]Elevations on the M. D. & S. R. R. are taken from the list given in Water-Powers of Georgia, Geol. Survey of Ga., Bull 3-A, pp. 98-100. Rough corrections were made according to the bench mark established on the Oconee River at Dublin by U. S. Army Engineers.

Dublin, low water level	U. S. A. Eng.	160.6	
Dudley	M. D. & S. R. R.	325	?
Dupont	A. C. L. R. R.	180	
East Albany	A. C. L. R. R.	186	
Eastman	U. S. G. S.	357	
Eden	C. of Ga. Rwy.	34	
Egypt	C. of Ga. Rwy.	132	
Eldorado	G. S. & F. Ry.	340	
Elko	G. S. & F. Ry.	443	
Ellabelle	S. A. L. Ry.	93	?
Ellaville	J. W. Spencer	591	
Empire	U. S. G. S.	382	
Esquiline	U. S. G. S.	300	
Eufaula, Alabama	C. of Ga. Rwy.	211	?
Everett City	U. S. G. S.	16	
Everett Station, Crawford County	C. of Ga. Rwy.	362	
Everett Station, Flint River, railroad bridge	C. of Ga. Rwy.	337	
Exeter	A. C. L. R. R.	94	
Exley	S. A. L. Ry.	63	
Faceville	A. C. L. R. R.	296	
Fargo	G. S. & F. Ry.	116	
Fitzgerald	A. B. & A. R. R.	388	?
Fitzpatrick	M. D. & S. R. R.	541	?
Fleming	A. C. L. R. R.	22	
Flint	A. C. L. R. R.	168	
Folkston	A. C. L. R. R.	80	
Fort Gaines	C. of Ga. Rwy.	163	
Fort Gaines, river level, low water		100	?
Fort Mudge	A. C. L. R. R.	134	
Fort Valley	C. of Ga. Rwy.	522	
Fowltown	A. C. L. R. R.	289	
Gallemore (Willis P. O.)	M. D. & S. R. R.	394	?
Gardi	U. S. G. S.	62	
Geneva (station)	U. S. G. S.	581	
Georgetown	C. of Ga. Rwy.	189	
Georgetown, low water, Chattahoochee River	Rough estimate	111	?
Glenmore	A. C. L. R. R.	151	
Godwinville	U. S. G. S.	312	
Gordon	C. of Ga. Rwy.	348	
Gordon, Alabama	A. C. L. R. R.	160	
Graham	Sou. Rwy.	240	
Graves	C. of Ga. Rwy.	350	
Greens Cut	C. of Ga. Rwy.	284	
Griswold	C. of Ga. Rwy.	447	
Grovania	G. S. & F. Ry.	444	
Groveland	S. A. L. Ry.	162	?
Grovetown	Ga. R. R.	495	
Guyton	C. of Ga. Rwy.	81	
Hagan	S. A. L. Ry.	186	?
Hahira	G. S. & F. Ry.	230	
Halcyondale	C. of Ga. Rwy.	110	
Halloca	U. S. G. S.	323	
Hardaway	A. C. L. R. R.	183	
Hardeeville, S. C.	A. C. L. R. R.	21	
Harlem	Ga. R. R.	548	
Hatcher	C. of Ga. Rwy.	289	?
Hawkinsville	Weather Bureau	235	

Hawkinsville, low water level	U. S. A. Eng.	200.2
Haylow	G. S. & F. Ry.	167
Hazlehurst	U. S. G. S.	256
Helena	U. S. G. S.	247
Hephzibah	Weather Bureau	402
Herndon	C. of Ga. Rwy.	179
Homerville	A. C. L. R. R.	176
Howard	C. of Ga. Rwy.	666 ?
Howell	G. S. & F. Ry.	169
Irwinton	Rough estimate	460 ?
Isabella (Sylvester)	A. C. L. R. R.	370
Jasper, Florida	A. C. L. R. R.	152
Jeffersonville	M. D. & S. R. R.	526
Jennings, Florida	G. S. & F. Ry.	150
Jesup	U. S. G. S.	100
Johnsonville, Jeff Davis County	Sou. Rwy.	240
Juniper Station	U. S. G. S.	422
Kathleen	G. S. & F. Ry.	330
Kingsland	S. A. L. Ry.	41
Kirkland	A. C. L. R. R.	200
Knoxville	J. E. Thomas	640
Lake Park	G. S. & F. Ry.	160
Lawton	C. of Ga. Rwy.	225
Leesburg	Rough estimate	300 ?
Lenox	G. S. & F. Ry.	300
Lewiston	C. of Ga. Rwy.	385
Lily	A. B. & A. R. R.	364 ?
Longstreet	U. S. G. S.	302
Louisville	Weather Bureau	259
Ludowici	A. C. L. R. R.	71
Lulaton	Rough estimate	50
Lumber City	U. S. G. S.	146
Lumber City, river level, low water	U. S. A. Eng.	84.7
Lumpkin (station)	Rough estimate	500
Lumpkin	Weather Bureau	650
Lyons	S. A. L. Ry.	254
McBean Station	C. of Ga. Rwy.	134 ?
McClenny, Florida	S. A. L. Ry.	125
McDonald	A. C. L. R. R.	167
McGriff	U. S. G. S.	259
McIntosh	A. C. L. R. R.	22
McRae	U. S. G. S.	230
McIntyre	C. of Ga. Rwy.	261
Macon, Union Station	G. S. & F. Ry.	334
Macon, near Sou. Rwy. Station	U. S. G. S.	311
Macon, low water level	U. S. A. Eng.	279.02
Macon Junction	C. of Ga. Rwy.	350
Manassas	S. A. L. Ry.	217
Marshallville	C. of Ga. Rwy.	500
Marlow	C. of Ga. Rwy.	72
Mayday	G. S. & F. Ry.	140
Mayfield	Ga. R. R.	417.5
Meigs	A. C. L. R. R.	341
Meinhard	S. A. L. Ry.	19
Meldrim	C. of Ga. Rwy.	28
Melrose	G. S. & F. Ry.	154
Metcalf	A. C. L. R. R.	170
Midville	C. of Ga. Rwy.	186
Milledgeville	Ga. R. R.	276

Milledgeville, low water level	U. S. A. Eng.	241.29
Millen	C. of Ga. Rwy.	156
Millwood	A. C. L. R. R.	160
Mineola	G. S. & F. Ry.	220
Moniac	G. S. & F. Ry.	114
Monteith	A. C. L. R. R.	16
Montezuma	C. of Ga. Rwy.	300
Montrose	M. D. & S. R. R.	391
Morgan	Weather Bureau	337
Morris	C. of Ga. Rwy.	242
Mount Pleasant	Sou. Rwy.	59
Munnerlyn	C. of Ga. Rwy.	264 ?
Muscogee	U. S. G. S.	245
Myers, Effingham County	S. A. L. Ry.	45
Naylor	A. C. L. R. R.	192
Nicholls	A. B. & A. R. R.	306 ?
Norwood	Ga. R. R.	588
Ochillee	U. S. G. S.	273
Ocklockonee	A. C. L. R. R.	263
Ochwalkee, low water Oconee R.	U. S. A. Eng.	114.4
Oconee	C. of Ga. Rwy.	223
Odum	U. S. G. S.	155
Offerman	A. C. L. R. R.	106
Ogeechee	C. of Ga. Rwy.	111
Oglethorpe	C. of Ga. Rwy.	299
Ohoopee	S. A. L. Ry.	187
Oliver	C. of Ga. Rwy.	140
Omaha (station)	Rough estimate	240
Ousley	A. C. L. R. R.	148
Paramore Hill	C. of Ga. Rwy.	235
Parrott	S. A. L. Ry.	482
Paschal	C. of Ga. Rwy.	669
Patterson	A. C. L. R. R.	104
Pearson	A. C. L. R. R.	205
Pembroke	S. A. L. Ry.	101
Pendarvis	U. S. G. S.	85
Pennick	U. S. G. S.	18
Pikes Peak (station)	M. D. & S. R. R.	534
Pinegrove	U. S. G. S.	229
Pinehurst	G. S. & F. Ry.	390
Pineora	C. of Ga. Rwy.	78
Piscola, Brooks County	Weather Bureau	190
Pooler	C. of Ga. Rwy.	23
Poulan	A. C. L. R. R.	345
Powersville	C. of Ga. Rwy.	385
Quitman	A .C. L. R. R.	173
Racepond	A. C. L. R. R.	148
Rebecca	A. B. & A. R. R.	373 ?
Recovery	A. C. L. R. R.	189
Register	Rough estimate	225 ?
Renfroes	S. A. L. Ry.	601 ?
Reynolds	C. of Ga. Rwy.	433
Riceboro	Rough estimate	15
Richland	S. A. L. Ry.	600
Richwood	G. S. & F. Ry.	358
Rincon	S. A. L. Ry.	75
River Junction, Florida	L. & N. R. R.	84
Roberta	Rough estimate	620
Roberts Station	Ga. R. R.	557

Rockyford	C. of Ga. Rwy.	130
Rogers	C. of Ga. Rwy.	159
Saffold	A. C. L. R. R.	105
Saffold, level of Chatt. R	Rough estimate	65
St. George	G. S. & F. Ry.	78
St. Mary's	Rough estimate	12
Sandersville	Rough estimate	470
Satilla	A. C. L. R. R.	96
Satilla, river level	A. C. L. R. R.	71
Savannah	A. C. L. R. R.	21
Scarboro	C. of Ga. Rwy.	147
Schlatterville	A. C. L. R. R.	133
Scotland	U. S. G. S.	142
Screven	A. C. L. R. R.	124
Shell Bluff Landing, Burke Co.	U. S. A. Eng. (low water)	87
Shell Bluff Landing, Burke Co.	U. S. A. Eng. (highest point)	237
Shellman	C. of Ga. Rwy	379 ?
Sibley	G. S. & F. Ry.	440
Smithville	C. of Ga. Rwy.	332
Sofkee	G. S. & F. Ry.	370
Soperton	Rough estimate	290
Sparks	G. S. & F. Ry.	241
Sparta	Ga. R. R.	557
Springfield	Rough estimate	100
Statesboro	Rough estimate	175 to 200
Sterling	U. S. G. S.	21
Stillmore (highest land)	Rough estimate	300
Stillwell, Effingham Co.	S. A. L. Ry.	69
Stockton	A. C. L. R. R.	187
Sulphur Springs	U. S. G. S.	300
Sumner	A. C. L. R. R.	373
Sunhill	C. of Ga. Rwy.	362
Surrency	U. S. G. S.	187
Swift Creek	M. D. & S. R. R.	324 ?
Sycamore	G. S. & F. Ry.	415
Sylvania	Rough estimate	200
Sylvester	A. C. L. R. R.	370 ?
Talbotton	U. S. G. S.	726
Tarrytown	Rough estimate	290 ?
Tennille	C. of Ga. Rwy.	469
Thalman	Rough estimate	20
Thelma	G. S. & F. Ry.	158
Thomas	C. of Ga. Rwy.	285
Thomasville	A. C. L. Rwy.	250
Thomson	Ga. R. R.	503
Tifton	A. C. L. R. R.	370
Tivola	G. S. & F. Ry.	300
Toomsboro	C. of Ga. Rwy.	227
Towns	U. S. G. S.	128
Tyty	A. C. L. R. R.	332
Unadilla	G. S. & F. Ry.	412
Upatoi	U. S. G. S.	418
Uptonville	A. C. L. R. R.	83
Valambrosa	M. D. & S. R. R.	258 ?
Valdosta	A. C. L. R. R.	215
Valona, McIntosh County	Weather Bureau	10
Vidalia	S. A. L. Ry.	257 ?
Vienna	G. S. & F. Ry.	350
Wadley	C. of Ga. Rwy.	234

A. INTERIOR OF BIG POND, SEVEN MILES NORTH OF BAXLEY, APPLING COUNTY.

B. A LIME SINK POND IN THE CHATTAHOOCHEE FORMATION, ON THE PROPERTY OF MRS. MITCHELL, SIX MILES WEST OF BOSTON, THOMAS COUNTY.

Wainwright (Uptonville Station)	A. C. L. R. R.	83	
Walden	C. of Ga. Rwy.	390	
Walthourville	A. C. L. R. R.	95	
Waresboro	A. C. L. R. R.	121	
Warrenton	Ga. R. R.	500	
Waverly	S. A. L. Ry.	17	
Waycross	A. C. L. R. R.	140	
Waynesboro	C. of Ga. Rwy.	286	
Waynesville	A. C. L. R. R.	55	
Ways	A. C. L. R. R.	18	
Wellston	G. S. & F. Ry.	315	
Wenona	G. S. & F. Ry.	348	
Westlake	U. S. G. S.	235	
Wheaton, Appling County	U. S. G. S.	201	
Whigham	A. C. L. R. R.	265	
Whiteoak	S. A. L. Ry.	19	
Willis (Gallemore)	M. D. & S. R. R.	394	?
Weston	S. A. L. Ry.	528	
Wilcox	Southern Rwy.	116	
Willacoochee	A. C. L. R. R.	247	
Willingham	A. C. L. R. R.	319	
Winchester	C. of Ga. Rwy.	463	
Woodbine	S. A. L. Ry.	20	
Worth	G. S. & F. Ry.	415	
Wray	A. B. & A. R. R.	392	?

GENERAL STATEMENT OF THE GEOLOGY OF THE COASTAL PLAIN

BY OTTO VEATCH

Georgia may be divided into three major geologic provinces: (1) the Paleozoic area; (2) the Crystalline area; (3) the Coastal Plain. The Coastal Plain is the largest division of the three, covering approximately 35,000 square miles, considered purely as a geologic division. The general physiography, location, boundaries, topography, etc., of the different areas have been presented in the preceding chapter.

The Paleozoic region is an area of limestone, shales, and sandstones which has been subjected to great dynamic movements and the sediments are highly folded and faulted. The strata range in age from lower Cambrian to the Coal Measures. The Crystalline area, including the Piedmont Plain and the Blue Ridge, is composed of rocks of igneous or metamorphic origin, including granites, gneisses, schists, basic eruptives, and highly metamorphosed shale, sandstone, and limestone. These constitute the oldest rocks of the State, and are probably in the main of pre-Cambrian age. They have been subjected to great orogenic movements, have been folded, faulted, and otherwise profoundly altered. Contrasted with the rocks of the Crystalline area those of the Coastal Plain are sands, clays, and marl, with a lesser amount of limestone and sandstone; they are to a large degree unconsolidated and have been altered but little, comparatively, from their original condition, with an entire absence of pronounced folding and faulting. The Coastal Plain sediments constitute the youngest series of beds in the State; they range in age from Cretaceous to Pleistocene and lie upon the upturned, planated beds of the ancient crystalline complex. They are mainly marine deposits, the component materials of which were derived from the crystalline complex to the north, their bulk representing the erosion of a vertical thickness of two thousand feet or more of beds from the Crystalline area of the State. The contact between these two major divisions, the Coastal Plain and the Crystalline area, is known as the Fall Line.

Divisions of Coastal Plain Strata.—The Coastal Plain deposits underlie an immense area and aggregate a maximum thickness of 4,500 to 5,000 feet of sediments which have resulted from separate deposi-

tions, and which correspondingly vary lithologically and faunally. Since to present a clear description *en bloc* of these sediments would manifestly be impossible subdivisions are necessary. While the structure of the Coastal Plain sediments is simple in comparison with that of the Piedmont, Blue Ridge, and Appalachian Valley rocks, this province, nevertheless, presents its peculiar difficulties and the classifications which have been arrived at in the different States represent laborious investigations covering many years. A table of the subdivisions made in Georgia is given on pages 60-61.

The great geologic periods, Cretaceous, Tertiary, and Quaternary, are based upon the life forms preserved in the rocks and great physical or climatic changes on the earth. The broader divisions, as Lower Cretaceous, Upper Cretaceous, Eocene, Oligocene, etc., based mainly upon life forms preserved in the rocks, are time divisions, and are also of wide application. The further subdivisions are provincial and still further minor subdivisions are local and are based upon fossils, peculiar lithologic character and stratigraphic continuity, and surface configuration or physiography, or a combination of all of these. To attempt to make mappable minor divisions of the strata entirely upon the basis of fossils or upon the basis of lithology alone, in either case leads to confusion. The study of fossils is carried on because of their value in correlating deposits of widely separated localities, the identity of which it is not possible to prove by stratigraphic continuity, or the actual tracing of a bed or formation.

Most of the formation and group names employed have been abstracted from literature on other States, and these names are here employed, as the formations of adjoining States are continuous with those of Georgia. Certain sections in Mississippi, Alabama, and Florida have been taken as standards for comparison for the Georgia formations for the reasons that stratigraphic studies were first prosecuted those localities.

Thickness.—The general lithologic character and thickness of the divisions are given in the accompanying table, and will be considered in detail in the following chapters, together with a discussion of their structure, fossils, etc. The aggregate thickness of the deposits, as has been mentioned, is 4,500 to 5,000 feet. Of this thickness, the Cretaceous forms 2,000 to 2,500 feet, the combined thickness of the Tertiary is approximately that of the Cretaceous, while the Pleistocene and Recent are but little more than 100 feet. Precise measurements of thickness can not be given, the principal reasons for which are: inconstancy in the strata, both along the strike and dip, the merging of strata faunally and lithologically, and paucity of fossil remains and of natural exposures.

TABLE OF GEOLOGICAL FORMATIONS IN

SYSTEM	SERIES	GROUP	FORMATION	MEMBER	THICKNESS[1] FEET
Quaternary	Recent				
	Pleistocene	Columbia	Satilla formation		10-50
			Okefenokee formation		5-40
Tertiary	Pliocene		Altamaha (Lafayette?) formation		150 ? (max.)
			Charlton formation		Undetermined
	Miocene		Duplin marl		10-15
			Marks Head marl		45
	Oligocene	Appalachicola	Alum Bluff formation		150 (average)
			Chattahoochee formation		150
			Vicksburg formation		800
	Eocene		Jackson formation		150
		Claiborne	Barnwell sand		100
			McBean formation	Marls, Sand &c.	100-400 (max.)
				Congaree clay member	
			Wilcox formation		150 (max.)
			Midway formation		400
Cretaceous	Upper		Ripley formation	Providence sand member	950 (approx.)
				Cusseta sand member	
				Marine beds	
			Eutaw formation	Tombigbee sand member	560
				Beds below Tombigbee sand member	
	Lower		Not differentiated		350-600

1. Precise measurements cannot be given; the reader is referred to the text for a discussion of the thickness of

THE COASTAL PLAIN OF GEORGIA

CHARACTER
Flood plain deposits, alluvial sand, marsh mud, swamp deposits, and beach sand.
Near the coast, mud and sand containing marine shells. Fluviatile phase, coarse sand, gravel and clay.
Coastal terrace phase, gray sand of perhaps beach origin, and argillaceous sand and small amount of gravel. Fluviatile phase, coarse sand and gravel.
Widely distributed; chiefly sand, clay and gravel; beds of coarse sandstone; or grit, and local beds of greenish and drab clay and clay-stone; devoid of fossils.
Soft, white argillaceous limestone, and laminated, fossiliferous, greenish clay; the deposits are exposed only in the bluffs of St. Marys River.
Sandy shell marl, slightly phosphatic.
Very sandy greenish or drab clay, fine, gray or brownish phosphatic sand and sandy laminated clays with calcareous nodules.
Marine deposits containing fossils, greenish or gray argillaceous sand and sandy laminated clays form the greater portion of the formation.
Gray and drab, compact fossiliferous limestone. Siliceous replacements at the base of the formation contain a rich coral fauna.
Mainly heavy bedded, soft, white fossiliferous limestone. The limestone is extensively silicified, and the formation is represented at the surface by red residual sand containing flint fragments. The formation also contains sand and clay beds.
Soft, heavy bedded, fossiliferous limestone and calcareous and glauconitic sandy clay.
Mainly red and vari-colored fossiliferous, marine sand; thin beds of silicified limestone or chert and sandstone and quartzite.
Variable in its lithologic character; mainly an argillaceous and sandy, fossiliferous marl, and drab, sandy clays and fuller's earth.
Dark colored, lignitic and glauconitic clay in the nature of fullers earth, and vari-colored, unconsolidated sand and clay.
Ferruginous sand and local beds of white clay, together with fossiliferous limestone, marl, clay and calcareous quartzite.
Gray, calcareous, micaceous sand; dark gray to black, sandy clay and shell marl with, at intervals, nodular layers of gray, calcareous sand or impure sandy limestone of marine origin; fine to coarse, crossbedded sand with subordinate lenses of light colored clay or dark, lignitic clay of shallow water origin.
Calcareous sand, sandy limestone, and more or less sandy clay of marine origin; crossbedded sands and clays of shallow marine or estuarine origin; at base of formation, arkosic, micaceous sand and dark gray to black clay containing lignite.
Coarse grained, crossbedded, arkosic sand with subordinate lenses of light-colored to pure white clays, approaching kaolin in composition; contains no marine fossils and is of shallow water, and presumably of fresh water, origin.

the various formations and members.

Structure.—The Coastal Plain strata have a general southward and coastward dip with the line of outcrops of the older formations running northeast-southwest. Conclusive proof of the foregoing statements is afforded by structural data obtained from natural exposures and deep wells, together with physiographic relations. The general surface slope, independent of the dip of the geological formations, from the Fall Line to sea level is about three feet per mile. The slope of the crystalline floor at the Fall Line is 50-75 feet per mile, but whether this slope is constant as far as the present coast can only be a matter of speculation, since the full thickness of the sediments in the lower part of the Coastal Plain has never been penetrated by boring. The oldest formations form the surface rock northward and disappear southward by reason of their dip, or in other words, in traversing the Coastal Plain from the Fall Line to the Atlantic Ocean and to the Gulf one descends from the oldest to the youngest or latest deposits. The dip of the Cretaceous beds is probably as much as 40 feet per mile; the lower Eocene beds have a dip of probably 20 to 30 feet; and the succeeding formations up to the Alum Bluff have a slope southward of not more than 8 to 15 feet per mile. The Alum Bluff formation has a very low southeastward and southward dip but the beds are, probably nearly horizontal near the Florida line. The Miocene beds as far as known are likewise almost horizontal. The Altamaha (Lafayette?) and Pleistocene deposits form a mantle over the older formations and conform to the general tilting of the plain.

The constancy of the dip of the older formations, and the constancy of lithologic phases, are matters of considerable economic interest, and it is regretted that more accurate information can not be given at present. The attainment of this information can be effected only by the further patient study of surface exposures and collection of accurate well data.

The Coastal Plain strata present no pronounced structural disturbances. Some local disturbances of beds of the Cretaceous and Eocene have been noted along the Chattahoochee River, and displacements of beds at other localities have also been observed. None of the observed local displacements are believed to be of magnitude and are probably unimportant incidents in the simple oscillations which the Coastal Plain has undergone.

Broad geologic structural features which can not be proven by recording strike and dip of the rock outcrops, since the dips are in gen-

eral so low that the strata appear horizontal, are suggested by peculiarities of the drainage. The evidence afforded by stream direction, together with geologic facts and elevations, makes the existence of certain structural features more than hypothetical.

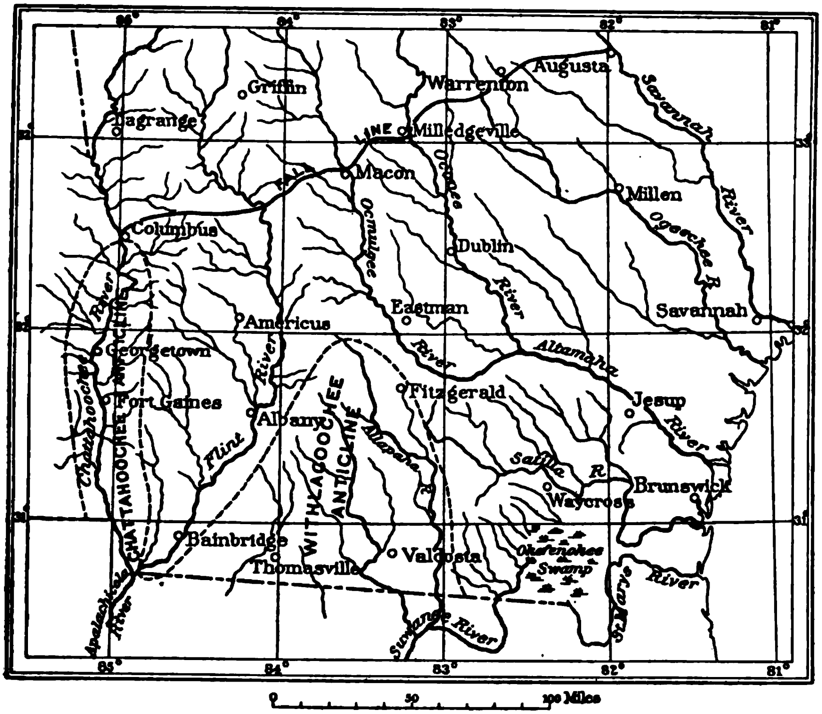


Fig. 5.—Sketch map of the Coastal Plain of Georgia, showing relation of drainage to geologic structure.

The nature of the drainage, together with certain geologic facts, suggests that the Chattahoochee River occupies the crest of a southward pitching anticline. (See Fig. 5.) The course of the Chattahoochee is almost directly southward in contrast to the southeastward courses of the other major streams—the Altamaha, Ocmulgee, Oconee, Ogeechee, and Savannah. Flint River has a southward course more or less parallel to the Chattahoochee and is apparently located in a broad syncline complementary to the Chattahoochee anticline. A glance at the map reveals a striking inequality in the drainage divides of the two rivers. The tributaries of the Flint are much longer, notwithstanding that the Chattahoochee is much the larger stream. The interpretation of this is that the Flint River tributaries

have been accentuated by the slope of the eastern limb of an anticline, whereas the Chattahoochee tributaries have developed under the adverse conditions present on the crest of an anticline. That there have been greater upward earth movements along the Chattahoochee than along the other rivers, is indicated by the much greater depth of the Chattahoochee valley, and the deep trench like channels which the main river and its tributaries have cut in the latest Pleistocene plain. The depth to which the river has cut into this late plain is 40 to 60 feet, while other large rivers have cut into it not more than 15 to 40 feet. The river is probably at present engaged in downward cutting since little or no flood-plain is developed along its course.

Geologic evidence of an anticline is afforded by the greater erosion and consequent exposure of the geologic formations along the Chattahoochee. The river has been able to cut into the older formations, revealing them with greater perfection than along any other Coastal Plain stream, probably by reason of the upward earth movements which have accelerated downward cutting. For example, the intercept of the Chattahoochee water level with the Vicksburg formation is about 50 miles farther south than the intercept on the Flint. The Vicksburg, however, closely parallels the river as far north as Fort Gaines, suggesting that a great width has been completely removed by erosion. Fort Gaines would probably have been near the intercept had the same strike of the formations prevailed in Georgia as in Alabama, and there had been no greater uplift along the Chattahoochee than along the Flint. Local disturbances of strata have been observed along the Chattahoochee, more so than in other parts of the Coastal Plain, and this may be considered evidence of a general, greater earth movement in this region.

The following elevations above sea level of the higher land bordering the Chattahoochee and the Flint are significant:

Comparative elevations along Chattahoochee and Flint Rivers.

Chattahoochee	Feet.	*Flint*	Feet.
Cusseta	540	Andersonville	394
Brooklyn	691	Americus	360
Richland	600	Smithville	332
Cuthbert	446	Albany	230[1]
Blakely	300[1]		

[1]Weather Bureau.

There is also physiographic and geologic evidence of a low fold or arch in the Oligocene strata, in the area drained by Ocklockonee, Withlacoochee, and Allapaha rivers, and extending along the Florida

line from Decatur to Echols counties and northward to Crisp and Wilcox counties (see fig. 5). The rivers mentioned flow south, whereas, normally, they would be expected to flow southeastward. The inequalities in the drainage divides of these streams and the Ocmulgee and Flint are significant of an original southward slope which determined the drainage direction. The absence of tributaries on the east side of the Allapaha and the direct southeast courses of the Satilla and its tributaries and the small streams entering Okefenokee Swamp, in contrast to the almost due south course of the Allapaha, suggest that a deformation of the strata must have taken place to produce these abnormal drainage features.

The elevations also suggest an anticline since, had the usual southeast slope prevailed, the elevations on the east side of the Flint would be less than those on the west side.

Comparative elevations on west and east sides of Flint River.

West Side	Feet.	East Side	Feet.
Americus	360	Ashburn	450
Smithville	332	Sylvester	370
Leesburg	300 (?)	Tifton	370
Dawson	326	Pelham	355
Armena	275 (?)	Climax	285
Blakely	300	Valdosta	215
Donaldsonville	139		

The limestone of the Chattahoochee formation appears in surface exposures in Lowndes, Brooks, Thomas, and Grady counties. This may be considered good evidence of an uplift, since, had the usual southeastward dip of the strata prevailed, the Chattahoochee formation would have been buried by later formations, as is the case in the eastern part of the Coastal Plain.

This broad arch or fold was formed some time subsequent to the deposition of the Alum Bluff formation, and may have been involved in the orogenic movement which produced the Chattahoochee anticline.

The southeastward courses of the Satilla, Altamaha, Ocmulgee, Oconee, Ohoopee, Ogeechee, Savannah, and other streams, suggest that the eastern half of the Georgia Coastal Plain is a monocline having a general southeastward pitch. The dip and strike of the geologic formations afford conclusive proof of the existence of this monocline.

CRETACEOUS

BY LLOYD WILLIAM STEPHENSON

INTRODUCTORY STATEMENT

The Cretaceous deposits of Georgia form part of a connected series of formations outcropping from central Georgia through Alabama, Mississippi, Tennessee, Kentucky, and the extreme southern part of Illinois. The area may be conveniently referred to as the eastern Gulf region.

The investigations conducted preliminary to the preparation of this report have not been confined to the State of Georgia, but have been extended along the whole area in which Cretaceous deposits occur in the eastern Gulf region. Nearly all the type sections of previously recognized geological formations have been studied, together with numerous additional localities. As complete sets of fossils have been collected as the semi-reconnaissance nature of the work permitted.

One of the important results of these investigations has been the demonstration of the fact that lithologic criteria alone can not be relied upon in establishing the stratigraphic and age relationships of the Upper Cretaceous deposits; for materials bearing a close physical resemblance may differ markedly in age and, conversely, materials very different in physical appearance may be contemporaneous. In such cases the relative ages can only be determined by a critical comparison of the contained life remains. This has been attempted and, although additional work is needed to fill in certain gaps, it is believed that sufficiently definite results have been obtained to warrant the main conclusions reached. The work of determining the fossils has been hampered by the fact that the types of many of the species have not been at hand for comparison, making it necessary to depend upon descriptions and published figures. Errors have doubtless been made which will be discovered in future monographic studies of the fossils. The lists given in the texts must, therefore, be regarded as of a preliminary character.

A preliminary report on the Cretaceous deposits of the eastern Gulf region has been prepared and will be published in the near future. The table, plate V, prepared from the data obtained through these general investigations, shows the lithologic variations and the age relationships of the eastern Gulf Cretaceous, and correlates these deposits with the Cretaceous of the Carolinas and the middle Atlantic region (Virginia, Maryland, Delaware, and New Jersey).

HISTORICAL REVIEW

The first investigator to recognize the presence of deposits of Cretaceous age in Georgia was Charles Lyell.[1] His conclusions were based on the results of observations made while traveling in North America in the years 1841-1842. In a statement explanatory of the general structure of the Coastal Plain of South Carolina and Georgia, he says:

"On the whole it appears, from the information I obtained, that the less elevated part of South Carolina and Georgia, intervening between the mountains and the Atlantic, has a foundation of cretaceous rocks, containing *Belemnites*, *Exogyra*, and other fossils, above which are, first, eocene limestones and marls, and secondly, the burrstone formation, with its red loam, mottled clays, and yellow sand."

Beds of Lower Cretaceous age near Augusta were examined by him, but he did not distinguish between them and overlying Eocene strata.

During a second visit to North America in the years 1845-1846 Lyell[2] visited parts of Georgia in which strata of Cretaceous age appear at the surface. The Cretaceous beds in the vicinity of Macon, Bibb County, were referred to the Tertiary, no distinction being made between them and the overlying fossiliferous beds of the Eocene. The Cretaceous age of some of the strata near Columbus was recognized. The following is quoted: (p. 33.)

"Columbus, like so many towns on the borders of the granitic and tertiary regions, is situated at the head of the navigation of a large river, and the rapids of the Chattahoochee are well seen from the bridge by which it is here spanned. The vertical rise and fall of this river, which divides Georgia from Alabama, amounts to no less than 60 or 70 feet in the course of a year; and the geologist should visit the country in November, when the season is healthy, and the river low, for then he may see exposed to view, not only the horizontal tertiary strata, but the subjacent cretaceous deposits, containing ammonites, baculites, and other characteristic fossils. These organic remains are met with some miles below the town, at a point called 'Snake's Shoals;' and Dr. Boykin showed us a collection of the fossils at his agreeable villa in the suburbs. In an excursion which I made with Mr. Pond to the Upotoy Creek, I ascertained that the cretaceous beds are overlaid everywhere by tertiary strata, containing fossil wood and marine shells."

In 1849 George White[3] gave a brief account of the geology of Georgia. Of the Cretaceous he says: (p. 21.)

"The *Cretaceous* formation is, with the exception of a small patch at Sandersville confined to parts of the counties of Randolph, Stewart, Mus-

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[1]Quarterly Journal, Geol. Soc. London, Vol. 1, 1845, pp. 429-442.
[2]A Second Visit to the United States of North America, London, 1849, 2 Vols.; 1st vol., 368 pp.; 2d vol., 385 pp. Especially 2d vol., p. 33.
[3]Statistics of the State of Georgia; Savannah, 1849 620 pp. Geological map of State at end. Especially pp. 21, 448, 495, 522.

cogee, Marion and Macon. Although its existence in these counties is well established by characteristic fossils, but little is known of the nature of the rocks in which they are found. A deposit in the Chattahoochie in Stewart County, from which the writer of this article, through the liberal exertions of H. T Hall, Esq., of Columbus, and I. C. Plant, Esq., of Macon, obtained teeth of the Geosaurus, Mosasaurus of an extinct crocodile, Lamna accuminata, and Galleus pristodatus, is identified with the ferruginous sand formation of New Jersey, as well as by the constitution of the soil as by its fossil remains.

"On the Petalau Creek in Randolph County (now Clay County), and at several other points, Ammonites placenta, Exogyra costata, Belemnites Americanus, and a large Cucullia have been found."

On a geological map of the State at the end of the volume, the Cretaceous is represented as covering a triangular area east of Chattahoochee River, cornering at Columbus, Knoxville, and the mouth of Pataula Creek on Chattahoochee River.

In 1853 Jules Marcou[1] published a geological map of the United States, in which the Cretaceous is represented as covering a triangular area in Georgia similar to that represented on the map of George White, but Macon is made the eastern corner of the triangular area instead of Knoxville.

In 1858, H. D. Rogers,[2] describing the distribution of Cretaceous deposits in the United States, said concerning their occurrence in the Eastern Gulf region: (p. 765.)

"The great continuous southern belt commences in Georgia near the Oconee River south of Milledgeville, and quickly expanding to a width of 60 or 80 miles, extends W. from the Flint River of that State through Alabama, where it sweeps around the S. promontory of the Appalachian chain and the Paleozoic formations, and stretches northward, holding about the same breadth, through Mississippi and western Tennessee as far as the W. corner of Kentucky."

An important contribution to the Paleontology of the Cretaceous of the Chattahoochee region made by T. A. Conrad[3] in 1860. He describes a large number of new species of invertebrate fossils from Eufaula, Barbour County, Alabama, collected by M. Tuomey, State Geologist. He correlates the horizon from which they were taken with Cretaceous beds at Owl Creek, Tippah County, Miss., from which he[4] had recently described 56 new species of invertebrates.

The general distribution and character of the Cretaceous deposits

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[1]A Geological Map of the United States and the British Provinces of North America; with an explanatory text, 92 pp., and eight plates of characteristic fossils. Boston. 1853.

[2]Sketch of the Geology of the United States, Geology of Pennsylvania, Vol. 2, 1858, pp. 741-778.

[3]Descriptions of New Species of Cretaceous and Eocene Fossils of Mississippi and Alabama. Jour. Acad. Nat. Sci., Phila., n. s. Vol. 4, 1858-1860, pp. 275-298, pls. 46-47.

[4]Conrad observations on a group of Cretaceous fossil shells, found in Tippah County, Mississippi, with descriptions of fifty-six new species. Jour. Acad. Nat. Sci., Phila., n. s., vol. 3, 1855-1858, pp. 323-336, pls. 34 and 35.

of the State were described by Dr. George Little, State Geologist of Georgia,[1] in 1876. He says: (pp. 38-39.)

"In the Mesozoic age, or Secondary of the old geologists, the Triassic and Jurassic periods—represented in other Atlantic States by sandstones, coal and trap dikes—show only the trap dikes of Meriwether, Habersham, and other counties, the sandstones, if they exist, being buried under the deposits of sand, clay, and sandy marls filled with the shells of various animals which lived in the *Cretaceous* age in the sea-water which washed against the hard granitic cliffs forming the shore line from Columbus to Butler. The greatest quantity of these remains is found on the banks of Pataula Creek, in Clay County. On examination, these shells prove to be unlike those of animals now living, and also different from those which are found in Northwest Georgia, in the rocks made in Paleozoic time; and hence, as they are intermediate, the age is called that of Middle Life, from the Greek word *mesos* (middle) and *zoe* (life). The forms correspond to those found in the Chalk Cliffs of England; and hence they belong to the Cretaceous age, from the Latin word *creta* (chalk).

"After the sea-bottom of the Cretaceous period was raised above the level of the water, the shore-line extended from Pataula Creek, by Butler, Macon, and Milledgeville, to the Savannah River at Augusta."

The Cretaceous deposits of central and western Alabama were described and classified by Prof. Eugene A. Smith and Mr. L. C. Johnson[2] in 1887. Four divisions of the Cretaceous were recognized, in ascending order, as follows: Tuscaloosa formation, referred questionably to the Cretaceous; Eutaw formation; Rotten limestone; and Ripley formation. The terms Tuscaloosa and Eutaw were used in essentially the same sense as understood by the present writer. The term "Rotten limestone" is synonymous with Selma chalk, later adopted for the same terrane. The Ripley formation appears to have included a portion of the upper part of the "Rotten limestone," and certainly sands and clays above the "Rotten limestone," since shown to be of Eocene age. The occurrence of Cretaceous deposits in eastern Alabama is not discussed in the text, but their supposed distribution in that region is indicated on a map accompanying the report. Two of the divisions, the Eutaw and Ripley formations, are represented on this map as extending eastward and intersecting the Chattahoochee River. The former apparently coincides approximately with the Lower Cretaceous terrane of the present report, and the latter includes all the Upper Cretaceous strata exposed on the river, embracing the Eutaw and Ripley formations of the present report.

The presence of Cretaceous strata along the fall line extending entirely across the State of Georgia, from Augusta to Columbus, was first recognized by J. W. Spencer.[3] He describes a formation resting

[1]Hand-book of the State of Georgia, accompanied by a Geological Map of the State. Atlanta, 1876. 256 pp.

[2]Tertiary and Cretaceous strata of the Tuscaloosa, Tombigbee, and Alabama rivers: U. S. Geol. Surv. Bull. No. 43, 1887, 189 pp., 21 pls., especially pp. 71-138.

[3]"Southern drift" and its agricultural relations: Bull. Exp. Station, Georgia, 1890. 5 pp.

upon the surface of decayed crystalline rocks in the fall line region, consisting of sands, clays, and gravels. The terrane is said to be generally covered with newer deposits, but is exposed along streams and in road and railway cuttings. He correlates these deposits with the Tuscaloosa formation of Alabama, and with the Potomac group of the Middle Atlantic region. The terrane corresponds to the Lower Cretaceous terrane of the present report. The same year W J McGee described briefly the character and relations of the Potomac formation (corresponding to the Lower Cretaceous of this report) in the vicinity of Macon, Bibb County, and Columbus, Muscogee County, Ga.[1]

The first detailed account of the Cretaceous deposits exposed on Chattahoochee River was furnished by D. W. Langdon.[2] A general section along the river from Columbus, Ga., to Alum Bluff, Fla., is given. Cretaceous strata appear in the river bluffs from Columbus to a point about eight miles above Fort Gaines, Ga. Three divisions are distinguished. The lowest of these, the "Tuscaloosa group," corresponds to the Lower Cretaceous of this report. Langdon mistook these Lower Cretaceous sands and clays for the eastward extension of the Tuscaloosa formation of Smith. The second division recognized, the Eutaw group, corresponds to the Eutaw formation of this report, minus the Tombigbee sand member. The third division recognized, the Ripley group, included the Tombigbee sand member of the Eutaw formation and the Ripley formation of the present report.

Commenting on the absence of the Rotten limestone (Selma chalk) in the Chattahoochee region, Langdon says: (p. 591.)

"East of the drainage of the Alabama River the Rotten limestone, such as occurs in Marengo, Perry, Dallas, Lowndes, and Montgomery counties, (Alabama), is not represented. The exact eastern limit of this group has not as yet been determined, but evidences of its decreasing thickness are seen in the narrow outcrop in the neighborhood of Pike road, Montgomery county, where its north and south extent is only five miles, as compared with thirty miles in Dallas County. Further than this decrease in thickness, present information does not warrant saying anything. As has been stated before, no rocks bearing any lithological resemblance to the Rotten limestone have been seen overlying the Eutaw group on the Chattahoochee River. Whether or not this group is represented by strata of different composition from the typical aluminous limestone it is difficult to say, since no critical examination of the fossils of the several divisions of the Cretaceous has yet been undertaken. It is much to be regretted that the divisions have been made on such arbitrary grounds as mere lithological differences, since marked variations can be noted in almost any stratum of any of the groups, and experience in both the Tertiary and the Cretaceous of Alabama has proved the risk of creating groups on any but combined physical and faunal differences."

[1]Southern extension of the Appomattox formation: Amer. Jour. Sci., 3d ser., vol. 40, 1890, pp. 15-41, especially pp. 22, 23.
[2]Variations in the Cretaceous and Tertiary strata of Alabama: Bull. Geol. Soc. America, vol. 2, 1890, pp. 587-606.

In 1891 J. W. Spencer[1] gave a brief account of the Cretaceous deposits in Georgia between the Chattahoochee and Flint rivers. He adopts Langdon's classification of the Cretaceous, and repeats his section along Chattahoochee River, (pp. 91-99). In a sketch map of the region between Chattahoochee and Flint rivers, the Cretaceous is represented as forming a belt intersecting the former river from Columbus to a point eight miles above Fort Gaines, and intersecting the latter river from Knoxville to Montezuma. The "Tuscaloosa formation," corresponding to the Lower Cretaceous beds of this report, is represented as forming a belt about eight miles wide along the northern edge of the Cretaceous area.

An admirable detailed report on the geology of the Alabama Coastal Plain, by Prof. Eugene A. Smith and Messrs. L. C. Johnson and D. W. Langdon,[2] appeared in 1894. No changes are made in the main divisions previously recognized, as announced by the same authors, in publications already cited. The Cretaceous age of the Tuscaloosa formation, previously referred questionably to the Cretaceous, is definitely assigned to that period. On the authority of Prof. Wm. M. Fontaine and Lester F. Ward, who studied the plant remains, the formation is correlated with the "Amboy clays" (Raritan formation) of the Middle Atlantic States, and with the Dakota "group" of the Western Interior. The name Selma chalk is proposed as a co-name with the term "Rotten limestone."

George E. Ladd[3] in 1898 published a preliminary report on the clays of Georgia. The fact, previously made known by Spencer, that a Potomac group equivalent is present in the fall line region, entirely across the State from Augusta to Columbus, is more clearly demonstrated. He describes in detail many of the exposures in the fall line region between the cities mentioned. The terrane described includes the strata referred to the Lower Cretaceous in this report.

In 1903, Prof. S. W. McCallie[4] described an interesting occurrence of sandstone dikes in the Cretaceous clays at Slick Bluff, Chattahoochee River. (See page 120 of this report.) He expresses the opinion that the dikes originated as sand fillings in fissures produced by earthquakes.

The clays and kaolins of the Cretaceous deposits of the State were

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[1]Geol. Surv. of Georgia. First report of progress, 1890-91, 128 pp. Especially pp. 26-40, and 91-99.

[2]Report on the Geology of the Coastal Plain of Alabama: Geol. Surv. of Ala., Montgomery, 1894, 759 pp., 29 plates, especially pp. 255, 372, 422, 445.

[3]A Preliminary Report on a Part of the Clays of Georgia; Geol. Surv. of Georgia, Bull. No. 6-A, 204 pp., 17 plates, especially pp. 85-165.
See also Notes on the Cretaceous and Associated Clays of Middle Georgia. Am. Geol., Vol. 23, 1899, pp. 240-249.

[4]Sandstone Dikes near Columbus, Georgia. Amer. Geol., Vol. 33, 1903, pp. 199-202.

briefly described by Otto Veatch[1] in 1907. Their general distribution and character are indicated and a number of specific localities are described.

In 1908, Prof. S. W. McCallie[2] published a report on the underground waters of Georgia, in which a brief account of the geology of the State is given. He adopts Langdon's classification of the Cretaceous. The entire Cretaceous is represented by one color on the geologic map.

The discovery of bauxite in Georgia in beds of Lower Cretaceous age was announced by Otto Veatch[3] in 1908. The deposit is located in Wilkinson County, near McIntyre. The ore occurs at the top of the Lower Cretaceous, and in the opinion of the author is an alteration product of the white clay or kaolin which is common in this terrane in Wilkinson County.

In 1908 Otto Veatch[4] gave a brief account of the remarkable white clays, or kaolins, occurring in the Lower Cretaceous, principally in Twiggs County. He discusses their geological occurrence, structure, and origin.

The Georgia Survey in 1909 issued a report on the clays of the State, by Otto Veatch.[5] A more complete account of the Cretaceous of the State than that contained in Professor McCallie's water resources report is given. Veatch recognizes the same main divisions of the Cretaceous as appear in Langdon's classification. The Ripley, however, he subdivides into four parts, namely, in ascending order, the "Blufftown marl," the Cusseta sand, the "Renfroes marl," and the Providence sand. A black and white map is given opposite page 88 of his report showing the distribution of the several Cretaceous divisions. His usage of names for Ripley subdivisions as compared with that adopted for the present report, is explained as follows: The "Blufftown marl" corresponds to the Tombigbee sand member of the Eutaw formation and to a part of the overlying Ripley formation; the Cusseta sand is the Cusseta sand member of the Ripley formation; the "Renfroes marl" is composed of characteristic Ripley materials and requires no special membership designation; and the Providence sand becomes the Providence sand member of the Ripley formation.

Detailed accounts are given of the Cretaceous clays of economic

[1]Kaolins and Fire Clays of Central Georgia: U. S. G. S. Bull. No. 315, 1907, pp. 301-314.

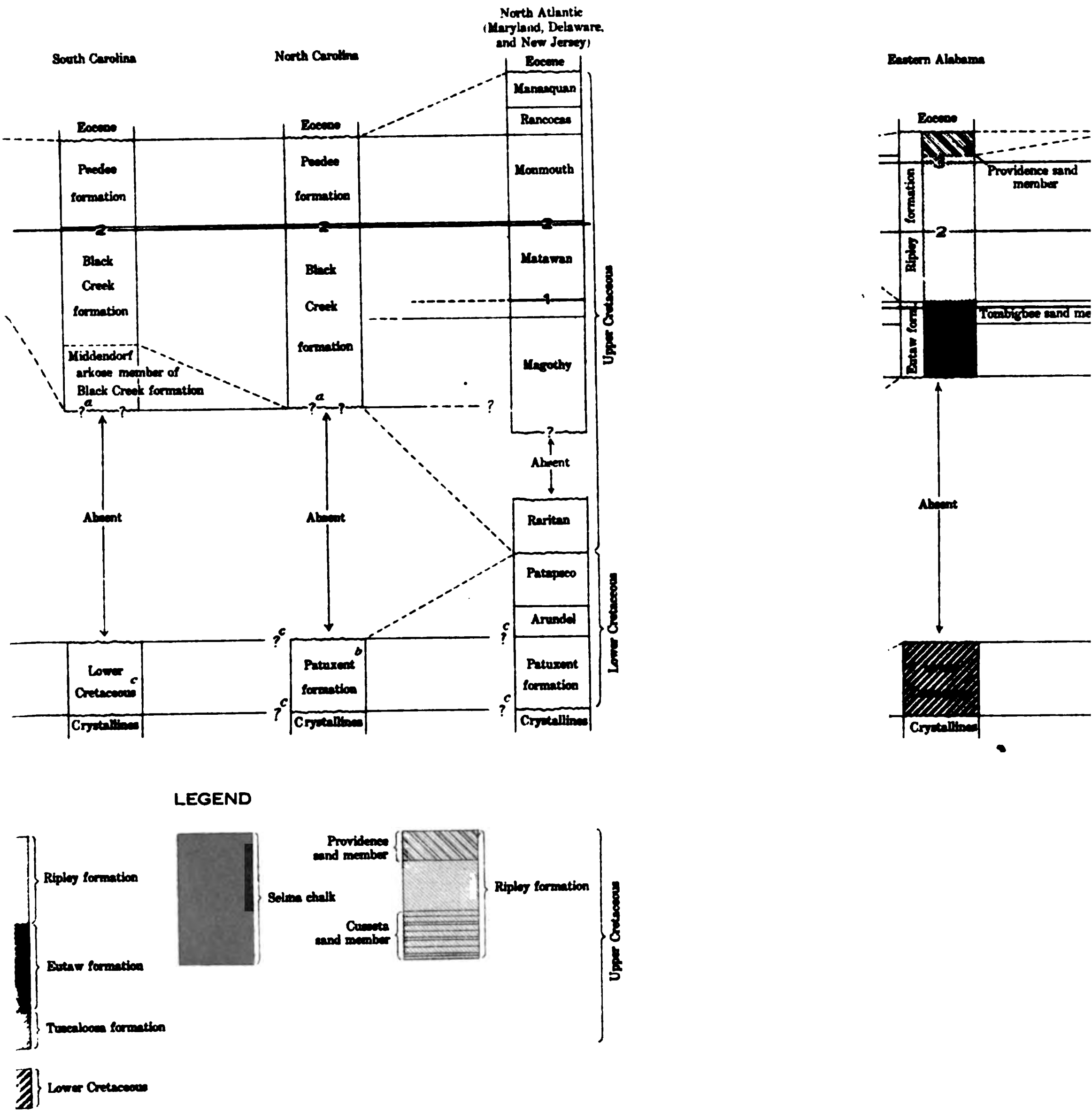
[2]Underground Waters of Georgia: Geol. Surv. of Georgia, Bull. No. 15, 370 pp., 29 plates, especially pp. 35-36, geological map opp. p. 32.

[3]A new discovery of bauxite in Georgia: Eng. & Min. Jour., vol. 85, 1908, p. 88.

[4]The kaolins of the Dry Branch region: Econ. Geol., vol. 3, 1908, pp. 109-117.

[5]Second report on the clays of Georgia: Geol. Survey of Ga., Bull. No. 18, 1909, 453 pp., 32 plates, especially pp. 82-106.

PLATE V



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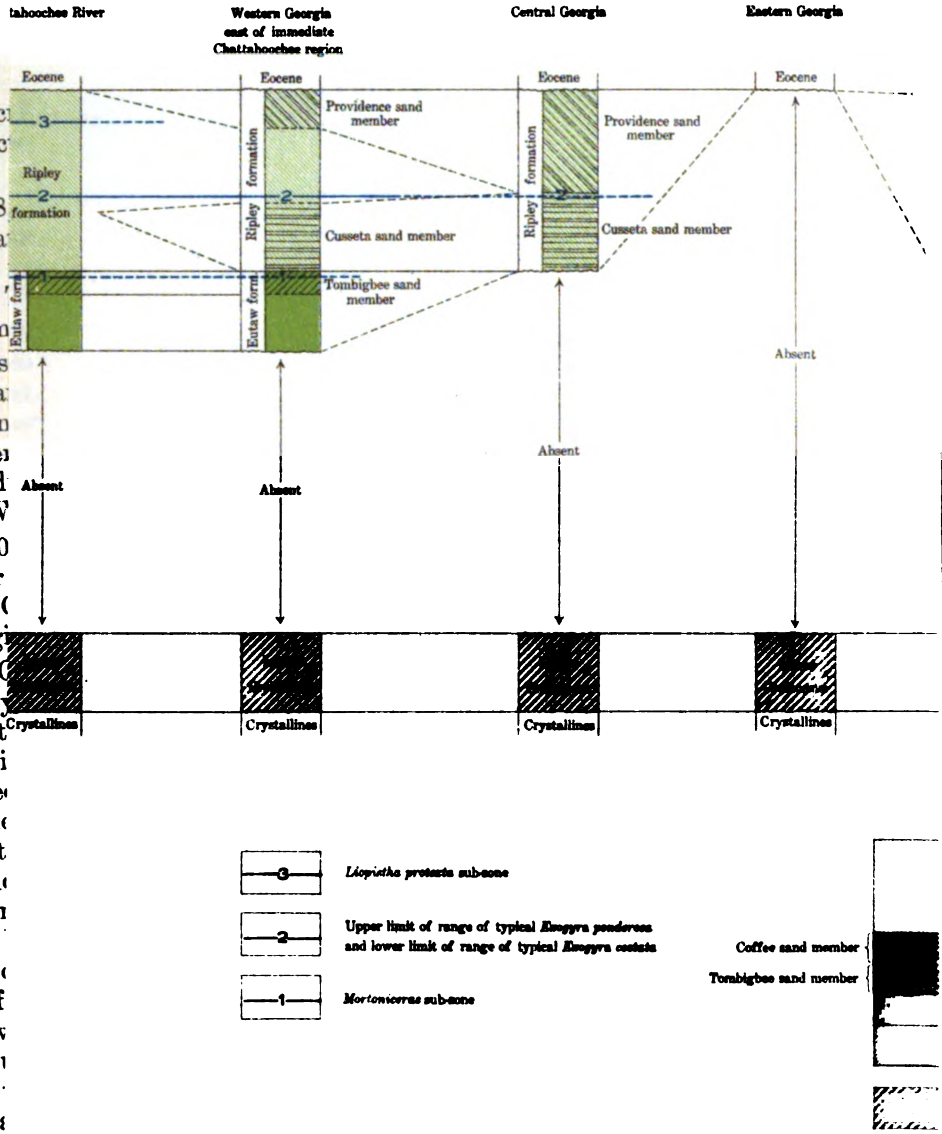

OF THE EASTERN GULF CRETACEOUS DEPOSITS, AND THE AGE RELATIONSHI
F THE REMAINDER OF THE EASTERN GULF REGION; ALSO THE CORRELATI
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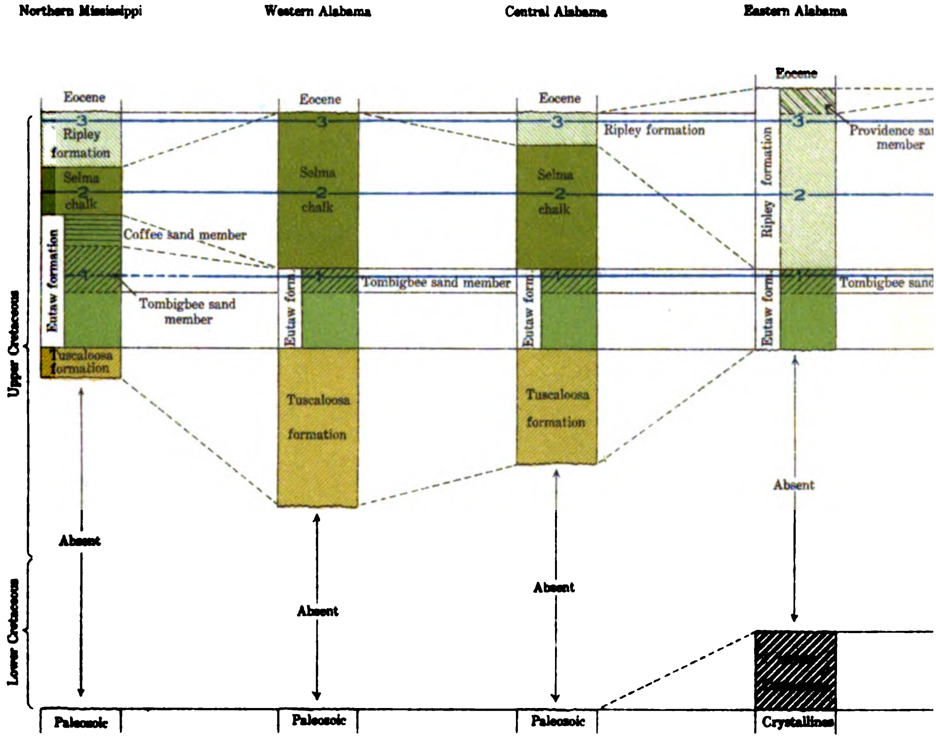
GEOLOGICAL SURVEY OF GEORGIA



a The stratigraphic position of the base of the Black Creek formation with reference to the eastern Gulf section has not been established with accuracy

b Correlated with the Patuxent formation on physical evidence only

c The synchroneity of the Lower Cretaceous strata of the eastern Gulf region with the Patuxent formation has not been established

Note: Within the Cretaceous portions of the columns age equivalencies are shown by horizontal lines, or may be determined by projecting horizontal lines

The spacing in the table does not indicate relative thicknesses of formations

Oblique dashed lines indicate the thinning or disappearance of formations or members either by the mergence of the beds along the strike into other types of materials, or by the pinching out of the beds by unconformity

TABLE SHOWING THE LITHOLOGIC VARIATI
DEPOSITS OF GEORGIA TO THO
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value, and Appendix D, pp. 430-447, is devoted to the bauxite deposits of the Lower Cretaceous beds.

Lists of species from the known Cretaceous fossil plant localities of Georgia were recorded by E. W. Berry[1] in 1910, and in the same paper a new genus and species of *Euphorbiaceæ* from one of the localities, McBride Ford, is described.

LOWER CRETACEOUS

DEFINITION

Areal distribution.—The Lower Cretaceous strata present in Georgia constitute a terrane whose exact correlation with reference to Lower Cretaceous deposits to the northward in the Atlantic Coastal Plain is at present not definitely known, but they are believed to represent a part of the Potomac group of the Middle Atlantic States. This terrane appears in surface outcrops in Georgia in an extremely irregular belt 2 to 30 miles in width, extending entirely across the State from Chattahoochee River in the vicinity of Columbus, northeastward to Savannah River in the vicinity of Augusta. The irregularities of the belt are due partly to the unevenness of the surface of the basement rocks upon which the formation rests; partly to overlaps of younger formations; and partly to the deep erosion valleys that the streams have developed along the fall line region, causing the underlying basement rocks to appear much farther southward in the bottoms of these valleys than would otherwise be the case, and likewise causing the Lower Cretaceous beds themselves to appear still farther down these valleys beneath the overlying younger formations. These irregularities are most strikingly developed in the region between Ocmulgee and Savannah rivers. (See geologic map, opposite page 58.) The area in which the beds appear includes parts of the following counties: Muscogee, Chattahoochee, Talbot, Marion, Taylor, Macon, Crawford, Bibb, Twiggs, Jones, Wilkinson, Baldwin, Washington, Hancock, Warren, Glascock, Jefferson, McDuffie, Columbia, and Richmond.

This Lower Cretaceous terrane continues westward from Georgia into Alabama, forming a belt four to eight miles wide lying just south of the Piedmont border, and extending to and probably somewhat beyond the Alabama River.

Stratigraphic position.—The Lower Cretaceous beds in Georgia rest upon a basement of ancient crystalline rocks, all of which are believed to be of pre-Cambrian age. The unconformity separating

[1]Contributions to the Mesozoic flora of the Atlantic Coastal Plain, VI Georgia: Bull. Torrey Botan. Club, No. 37, 1910, pp. 503-511.

the basement rocks from the Lower Cretaceous deposits represents an enormous time interval, including all of Paleozoic time, and the Triassic and Jurassic periods of Mesozoic time. The surface of the crystalline rocks is very uneven in detail, but in general, slopes to the south and southeast beneath the Lower Cretaceous beds. Calculations from well borings at several places have shown that the amount of this general slope in the region of the fall line varies from 25 to over 50 feet to the mile. In Jefferson County it maintains a slope of between 35 and 40 feet to the mile for a distance of nearly 40 miles away from the Piedmont border.

Between Chattahoochee and Ocmulgee rivers the formation is overlain unconformably by Upper Cretaceous strata belonging to the Eutaw and Ripley formations, and to a very limited extent, when both of these formations are absent, by Eocene strata; between Ocmulgee and Savannah rivers it is overlain unconformably by Eocene strata of the Claiborne group. Locally, where the formation is crossed by the larger streams, it is overlain along the valley sides by thin Pleistocene terrace deposits.

The unconformity separating the Lower Cretaceous deposits from the overlying Eutaw formation has been observed at a number of places in Muscogee and Chattahoochee counties, Ga. (see detailed sections); but the locality where it is best exposed and least obscured by weathering, as thus far observed, is in Russell County, Ala., four miles southwest of Columbus, Ga. The contact at this point is sharp and unmistakable. Its character is well shown in the photograph, plate VI, B. The contact has also been observed on Alabama River, five miles above Montgomery.

A short distance west of Alabama River in Alabama the formation pinches out entirely between the basement rocks and the overlying Tuscaloosa formation, allowing the latter to rest directly upon the basement floor.

Lithologic characters.—The Lower Cretaceous materials consist predominately of arkosic sand, with, however, a considerable percentage of clay in the form of interbedded lenses. The sands are usually coarse to very coarse in texture, and cross-bedding is general. They are composed largely of angular to subangular quartz grains, with, however, an important percentage of kaolin grains and disseminated kaolin particles. In addition, there are subordinate amounts of undecomposed feldspar, mica, and various other minerals derived from the crystalline rocks of the adjacent Piedmont region. Locally, the sand beds have been indurated, forming friable sandstones. The clay lenses vary widely in lithologic character, shape, and extent. In thickness they range from an inch or less to a maximum of 30 or 40

feet, and in horizontal extent from a few square feet to many acres. In general, the clays are light drab or gray in color, and are more or less sandy. Locally, however, there are commercially important clay lenses of remarkable whiteness and purity approaching kaolin in composition. Lamination is rare, the beds being as a rule massive and breaking with a hackly or conchoidal fracture.

For the most part the formation displays great irregularity of bedding. In places, however, a distinct banding of the clay and sand layers is apparent, individual beds being traceable for considerable distances. Good examples of the latter type of bedding are presented by the bluffs of Chattahoochee River below Columbus.

Locally, coarse gravel lenses and layers occur in the formation, this being especially true of the basal portions near the contact with the underlying crystalline rocks. Unconformities of little or no time significance occur locally within the formation. As the result of the shifting of the channels which produced these unconformities clay beds within the formation have been torn to pieces and redeposited, as evidenced by the large number of rolled clay balls and boulders which in many places occur scattered through the sands. The better grades of commercially important clays, so far as known, occur in the region between Ocmulgee and Savannah rivers. Beds of very fine quality are abundantly developed in Twiggs County and here mining operations have been carried on more extensively than elsewhere. The same formation contains similar high grade white clay beds to the northward in Aiken County, S. C.

In Wilkinson County the white clays have been locally altered to bauxite with pisolitic structure. The bauxite deposits, so far as known, occur immediately beneath the contact of the formation with overlying Eocene strata. The white clay and bauxite deposits have been described in considerable detail by Otto Veatch.[1]

Strike, dip, and thickness.—The strike of the Lower Cretaceous beds in Georgia is in general a little south of a northeast-southwest direction. In Alabama the strike is almost due east and west. There is a slight general dip of the beds to the southeast or south at right angles to the line of strike. On account of irregularity of bedding, and also on account of the limited extent of the exposures, the exact amount of dip can not be readily determined. It is greater, however, than the gradients of the larger streams and probably averages 25 or 30 feet to the mile. Data are available for a fairly accurate determination of the thickness of the formation in the Chattahoochee Valley below Columbus. The point on Chattahoochee River adjacent to

[1]Geol. Survey of Georgia, Bull. No. 18.

Columbus, where the surface of the basement rocks passes beneath zero water level, has an elevation of about 195 feet above sea level. Data furnished by well borings near the mouth of Bull Creek show that this surface dips southward beneath the Lower Cretaceous beds at an average rate of between 50 and 60 feet per mile. The top of the Lower Cretaceous terrane passes beneath water level at Broken Arrow Bend, an air-line distance of seven miles south of Columbus, at an elevation of about 180 feet above sea level. If the dip of the surface of the basement rocks is 50 feet to the mile, seven miles south of Columbus at Broken Arrow Bend, it would be 350 feet lower, or 155 feet below sea level. The thickness of the formation at this point would therefore be 155 feet + 180 feet, or 335 feet. If the dip of the basement rock surface is 60 feet to the mile instead of 50 feet the same method of calculation would give the thickness at 405 feet. Three hundred and seventy feet, the average of these amounts, is believed to be a close approximation to the total thickness at this point.

Calculations based upon well data have shown that the probable general dip of the unconformity separating the Lower Cretaceous and overlying Eutaw beds in this region is 48 or 50 feet to the mile. This slope is therefore probably a little less than the slope of the surface of the underlying basement rocks. If these two plains maintain their respective degrees of dip they must diverge slightly and the formation must thicken somewhat to the southward. It seems improbable, however, that the buried surface of the basement rocks maintains so great a degree of slope southward for any great distance away from the fall line as it is known to possess in close proximity to the fall line.

A well at Reynolds, Taylor County, is said to have penetrated 600 feet of Cretaceous strata before encountering the underlying crystalline rocks. As the well starts in Lower Cretaceous strata this whole thickness, 600 feet if correctly reported, should be referred to this formation.

Three and one-half miles southwest of Louisville, in Jefferson County, a well 1,143 feet deep is believed to have penetrated about 790 feet of Cretaceous strata between the overlying Eocene deposits and the basement rocks. None but Lower Cretaceous strata outcrop at the surface from beneath the Eocene beds along the fall line to the northwest of Louisville, but it is not at all certain that all of the Cretaceous beds penetrated in the Louisville well should be referred to that division. In fact it seems highly probable that buried Upper Cretaceous strata exist between the Eocene and Lower Cretaceous beds. The thickness of the Lower Cretaceous terrane at this point is therefore believed to be considerably less than 790 feet.

From data obtained from wells, and from other considerations, it may be shown that in general along the line where the formation passes beneath the overlying Upper Cretaceous or Eocene formations, as the case may be, its thickness ranges from 350 to 600 feet, although the amount may be less or greater locally.

Physiographic expression.—The belt in which this Lower Cretaceous terrane outcrops at the surface constitutes part of a dissected plain which is characterized by a broken, hilly topography, the area presenting in fact the roughest surface of any portion of the Coastal Plain of Georgia. The elevation of the upland surface ranges from 400 to 600 feet above sea level. The major streams crossing the area have elevations at the fall line at zero water level, ranging from about 100 feet to about 250 feet. The surface relief therefore reaches a maximum of at least 400 feet. This hilly topography is the result of active stream erosion caused by the relatively high elevation of the area and favored by the unconsolidated, sandy character of the materials of which the formation is predominantly composed.

The surface soil throughout the greater part of the area is composed of loose gray or yellowish sands; the product of the weathering and leaching of the underlying sand beds of the formation. These surface sands have been shifted more or less by winds and torrents so that in places they have been entirely removed, and elsewhere have been heaped up to abnormal thicknesses. The area forms a part of the so-called "sand hill" region of the northern part of the Georgia Coastal Plain.

Paleontologic characters.—A few, faint, indeterminable leaf impressions have been observed in white, sandy clay in a cut of the Georgia Railroad at Carr's Station, Hancock County. With this exception no fossil remains have been discovered in the beds of this formation in Georgia.

A few poorly-preserved leaf remains were recently collected by the writer from this terrane at an exposure in a bluff of Tallapoosa River at Old Fort Decatur, Macon County, Alabama. These were submitted to E. W. Berry, who expresses the opinion that the beds containing them are of Lower Cretaceous age, and they are believed to represent a part of the Potomac group of the Middle Atlantic States. Further reference will be made to these in the section on correlation, pp. 108-111. The cast of a *Unio,* specifically indeterminable, was found in close association with the plant remains at this locality.

DETAILED SECTIONS

Chattahoochee River.—Lower Cretaceous strata are exposed in the bluffs of Chattahoochee River from Columbus, Muscogee County, to Broken Arrow Bend, Chattahoochee County. The specific localities referred to on the following pages are indicated in a sketch map of the river, Figure 6.

At Columbus the Lower Cretaceous beds rest unconformably upon a basement of ancient crystalline rocks. The latter form the body of the hills north of the city and give rise to the rapids in the river opposite the northern half of the city. Their surface dips rapidly to the southward under the Coastal Plain sediments, passing beneath water level a short distance below the Central of Georgia Railway bridge. The following section shows the relation of the Lower Cretaceous strata to the underlying basement rocks and to the overlying Pleistocene terrace deposits.

Section, Chattahoochee River, bluff at Girard, opposite Columbus, at west end of Central of Georgia Railway bridge.

	Feet.	In.
Pleistocene (terrace deposit)		
7. Red, coarsely arenaceous clay	6	
6. Reddish and yellowish, argillaceous sand and sandy clay, coarse and pebbly, with pockets of pebbles, becoming much coarser along base	14	
5. Dark, tough, plastic, sandy clay with indeterminable plant fragments	11	
4. Coarse, irregularly bedded sand and gravel, the pebbles averaging ¼ to ½ inch in diameter and angular to partially rounded	1	6
(Unconformity)		
Lower Cretaceous		
3. Light drab, massive, coarsely sandy, compact clay	9	
2. Argillaceous, very arkosic, light gray, friable sandstone	3	
(Unconformity)		
Basement rocks		
1. Deeply decayed crystalline rock (gneiss) to low water level	5	

On the south edge of the town of Girard, west of the Central of Georgia Railway track, there is an excellent exposure of Lower Cretaceous strata in a sand pit. The succession of beds as they appeared when visited, is as follows:

Section at southern outskirts of Girard, Ala.

	Feet
Pleistocene? (or surface creep).	
6. Sandy and pebbly loam	2
(Unconformity)	
Lower Cretaceous	

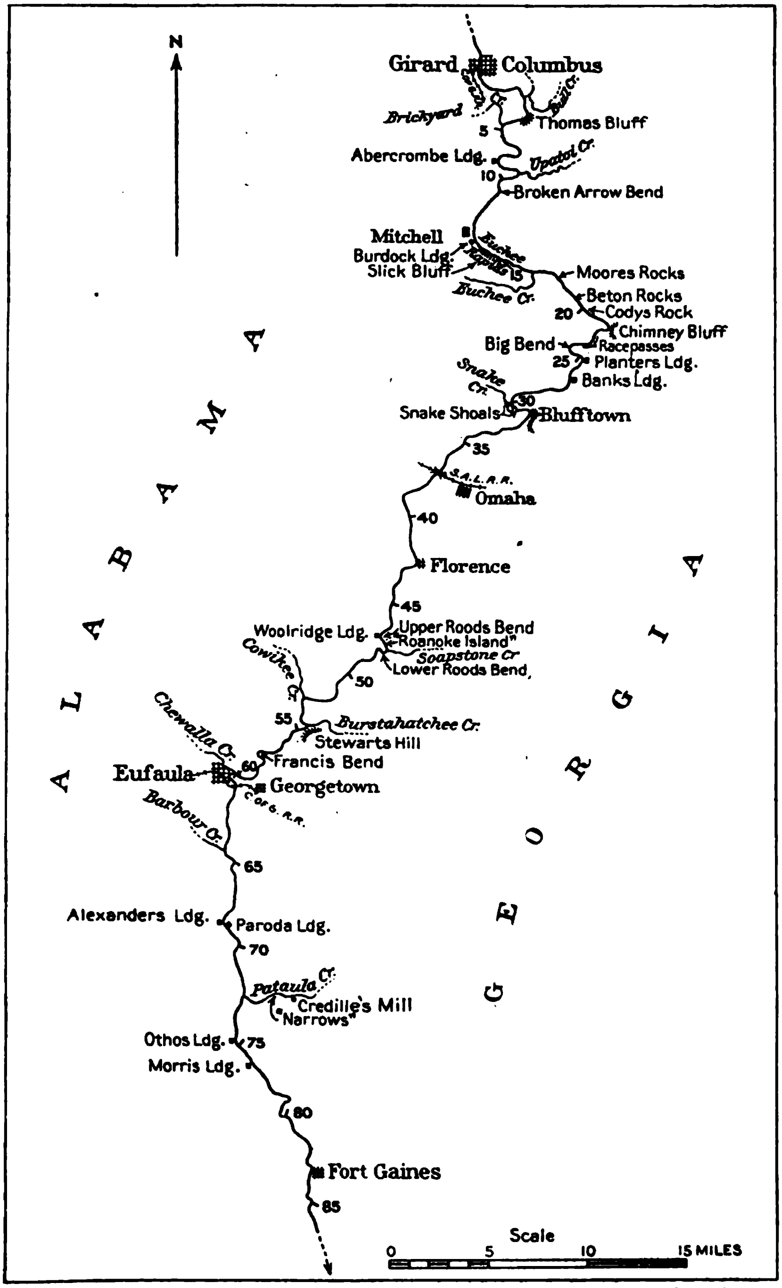


Fig. 6.—Sketch map of Chattahoochee River, Columbus, Ga., to Fort Gaines, Ga.

5. Reddish sandy loam, grading down into harsh, sandy clay, and this in turn into a slightly indurated, arkosic, micaceous sand	25
4. Mottled purplish and gray, harsh clay	3
3. Hard, grayish to somewhat mottled, sandy clay	6
2. Gray, in places iron-stained, loose, cross-bedded, very arkosic and micaceous sand becoming very coarse and gravelly in lower six feet	16
1. Light, greenish drab clay	12

The base of the preceding section is 30 or 35 feet above zero water level in the river.

The first prominent exposure immediately on the river below Columbus is at a point about one-half mile above the mouth of Bull Creek on the Georgia side. The section in detail is as follows:

Section one-half mile above the mouth of Bull Creek, Chattahoochee River, left bank.

	Feet	
Pleistocene (terrace deposit)		
4. Yellowish sandy loam grading down into coarse sand and gravel	33	
(Unconformity)		
Lower Cretaceous		
3. Light gray to white, very coarse, cross-bedded, arkosic sand, containing pebbles up to ¼ inch in diameter	13	
2. Harsh, greenish gray clay, mottled with brown	2	6
1. Greenish gray, finely micaceous, argillaceous sand, to water's edge	3	

The cross-bedded, arkosic layer in the preceding section undulates along the bluff but in general dips gently southward and comes to water level a few hundred feet below where the section was made.

A section similar to the preceding occurs at the mouth of Bull Creek.

Thirty-nine wells have been recently drilled in Muscogee County about three miles southeast of Columbus, on either side of Bull Creek and within one mile of its mouth. All passed entirely through the Lower Cretaceous beds and entered the underlying basement rocks. Logs of two of these wells are given below. Mr. N. W. Wood, Constructing Engineer of the Hudson Engineering Company, 90 West Street, New York City, N. Y., is authority for the lithology.

A. CLAY PIT AT PLANT OF THE GEORGIA KAOLIN COMPANY, TWO MILES SOUTHEAST OF DRY BRANCH, IN TWIGGS COUNTY, GA., SHOWING CONTACT BETWEEN WHITE KAOLIN BED OF THE LOWER CRETACEOUS AND OVERLYING SANDS AND CLAYS OF THE CLAIBORNE GROUP (EOCENE).

B. EXPOSURE IN CUT OF COLUMBUS-SEALE ROAD, FOUR MILES SOUTHWEST OF COLUMBUS, GA., IN RUSSELL COUNTY, ALA., SHOWING CONTACT BETWEEN LOWER CRETACEOUS BED AND THE OVERLYING EUTAW FORMATION.

Log of Well No. 11, located about 600 feet southeast of the mouth of Bull Creek.

		Feet	
Lower Cretaceous (except a few feet of undifferentiated Pleistocene terrace material at top)			
16.	Clay	0 to	56
15.	Soft sand rock	56	60
14.	Harder sand rock	60	94
13.	Sand, with small amount of water	94	104
12.	Clay, light in color	104	107
11.	Sand	107	111
10.	Clay, light in color	111	117
9.	Hard sand	117	126
8.	Red clay	126	136
7.	Sand, water-bearing	136	145
6.	Red clay	145	155
5.	Sand, water-bearing	155	158
4.	Yellow clay	158	160
3.	Sand rock	160	173
Basement rocks			
2.	Decayed top of crystalline rock	173	202
1.	Hard crystalline rock	202	261

Log of Well No. 25 located about 4,000 feet southeast of Well No. 11.

		Feet	
Pleistocene (terrace deposit)			
27.	Clay	0	17
26.	Sand and gravel	17	27
Lower Cretaceous			
25.	White sand rock	27	31
24.	Brown sand rock	31	38
23.	White sand rock	38	46
22.	Brown sand rock	46	55
21.	Gray sand rock	55	69
20.	Brown sand rock	69	77
19.	Yellow, sandy clay, soft and sticky	77	98
18.	White sand, water bearing	98	117
17.	White sandy clay, sticky like putty	117	125
16.	Dark yellow clay	125	134
15.	Blue sandy clay	134	142
14.	Yellow clay	142	147
13.	Blue sandy clay	147	156
12.	Red clay, shaly	156	165
12.	White sand, small amount of water	165	179
10.	Red clay, shaly	179	190
9.	Yellow sandy clay	190	194
8.	White coarse sand, water bearing	194	210
7.	Red clay, shaly	210	215
6.	Yellow sandy clay	215	220
5.	Gray sandy clay, lead color	220	229
4.	Tough, micaceous clay resembling residual mica schist	229	234
3.	Micaceous silt	234	245
Basement rocks			
2.	Soft gray decomposed crystalline rock	245	250
1.	Hard crystalline rock	250	267

At Thomas Bluff, one mile below the mouth of Bull Creek, Lower Cretaceous materials are exposed as described in the following section:

Section at Thomas Bluff, Chattahoochee River, Georgia, one mile below the mouth of Bull Creek, left bank. (See plate VII, A.)

		Feet
Pleistocene (terrace deposit)		
2.	Sandy loam at top grading down into sand with a band of gravel along base	30
	(Unconformity)	
Lower Cretaceous		
1.	Light gray and greenish gray compact, very arkosic, micaceous, coarse sand with many pebbles up to 1 inch or more in diameter, and in one layer 7 or 8 feet above base water-worn chunks of greenish gray, micaceous clay up to 8 inches in diameter. The sand shows decided cross-bedding at many places	22

At a point about five and one-half miles below Columbus, and one-half mile below the mouth of Brickyard Creek, right bank, the base of the bluff at low water exposes about six feet of Lower Cretaceous purplish sand and clay. This is overlain by 25 or 30 feet of Pleistocene terrace materials. The upper surface of the Lower Cretaceous beds slopes down stream and in a distance of about one-quarter mile passes beneath water level, the bluff below this point presenting Pleistocene strata from top to base. The Pleistocene materials consist of loam, sand, and gravel, having a total thickness of 35 feet. The gravel forms the basal portion of the section, the bed reaching a maximum thickness of 12 feet in places.

From this point to the mouth of Upatoi Creek, with the exception of a few low exposures of Lower Cretaceous clay, the bluffs present only Pleistocene strata, in places showing heavy beds of gravel in the basal portions.

The Eutaw formation, which overlies the Lower Cretaceous terrane in this region, makes its first appearance on the river in a bluff a short distance below the mouth of Upatoi Creek. The character of the materials and the relations of the formations are described and figured below.

Section below the mouth of Upatoi Creek, Chattahoochee River, nine miles below Columbus, left bank.

		Feet
Pleistocene (terrace deposits)		
4.	Sandy loam, grading down into clay and this in turn into sand	14
3.	Sand and gravel with cobbles at base up to 6 inches in diameter. Also occasional pieces of petrified wood, and one large petrified log in gravel near base	7
	(Unconformity.)	

Upper Cretaceous
Eutaw formation
2. Dark gray, finely arenaceous and micaceous clay with occasional grains of glauconite, containing a few poor impressions of pelecypods near top. Contains iron carbonate concretions with poor shell impressions, and occasional pieces of lignite . . . . 1 to 5
(Unconformity)
Lower Cretaceous
1. Light greenish gray, sandy, micaceous clay, to water's edge . . . . 0 to 3

A sketch of the face of bluff where the preceding section was made is given in fig. 7.

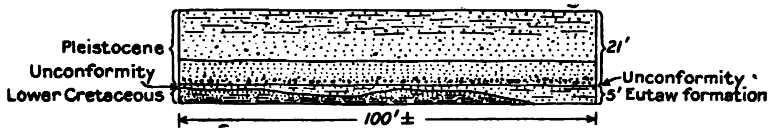


Fig. 7.—Sketch showing relation of Lower Cretaceous beds to Eutaw formation at bluff below mouth of Upatoi Creek.

The last exposure of Lower Cretaceous strata seen in descending the river is in a bluff on the left bank at Broken Arrow Bend, 10½ miles below Columbus. Characteristic arkosic sands and clays form the base of the section, rising four or five feet above water level at one or two places along the face of the bluff. They are overlain unconformably by laminated sands and clays and fossiliferous marine sands of the Eutaw formation.

Region between Chattahoochee and Ocmulgee Rivers.—Numerous exposures of Lower Cretaceous strata occur east of Chattahoochee River in Muscogee County, and in the extreme northern part of Chattahoochee County. A number of sections have been examined, some of which show the relations of the beds to the underlying basement rocks, and some to the overlying Eutaw formation.

The beds described in the section given below appear in a road cut of the Columbus-Macon road at the eastern edge of the city of Columbus.

Section on Columbus-Macon road, a short distance east of Wercoda Creek, near the eastern outskirts of Columbus, Ga., on the face of the scarp separating the first and second Pleistocene terrace plains.

	Feet.
Pleistocene. (Second terrace above river.)	
4. Sandy loam and sand	15 or 20
(Unconformity.)	
Lower Cretaceous	
3. Fine, arkosic, micaceous sand	4
2. Light gray, stratified, coarse, very arkosic, micaceous sand, streaked with iron stain. The kaolin grains reach a maximum of ¼ inch in diameter . . about .	7
1. Gray or drab clay, not well exposed	3

A remnant of Pleistocene terrace deposits consisting of reddish and yellowish, argillaceous, pebbly sand, with gravel band along the base, rests unconformably upon the Lower Cretaceous strata on the face of the scarp at the preceding locality.

An exposure exhibiting an indurated phase of the coarse, arkosic sand of this terrane occurs on the Columbus-Macon road, three and one-half miles northeast of Columbus. The section is described below. (See plate VII, B, opposite page 88.)

Section on Columbus-Macon road, three and one-half miles northeast of Columbus, Ga.

	Feet
Lower Cretaceous	
3. Light gray, extremely coarse, very arkosic, pebbly sand, the sand grains and pebbles angular. The pebbles consist principally of quartz, reaching maximum diameters of several inches, but there is a considerable intermingling of feldspar fragments. Along the base occur large chunks of mechanically introduced clay	10
2. Light gray, very coarse, friable, arkosic sandstone, with texture similar to preceding	5
1. Light gray, somewhat finer, compact arkosic sand	2

The road to the northeast of the preceding exposure passes up a hill about 50 feet in height in a distance of one-quarter mile. Poor exposures in the road ditches reveal materials similar to the preceding with subordinate clay lenses. Coarse gravels appear in the upper part of the section, but whether these should be referred to the Lower Cretaceous or to a younger surficial formation has not been ascertained.

Gravels similar to those just mentioned cap the hills to the west and east of Cooper Creek on the same road. The body of these hills is made up of Lower Cretaceous coarse, arkosic sands and sandy clays. Small exposures of the formation occur along this road still farther to the northeastward. At a point seven miles northeast of Columbus the contact of the formation with the underlying basement crystallines appears in a road ditch exposure. A section made at this place is given below.

Section, Columbus-Macon road, 7 miles northeast of Columbus, Ga.

	Feet
Lower Cretaceous	
3. Argillaceous sand and gravel with creep gravel extending a considerable distance down the hill slope	10
2. Coarse arkosic sands with subordinate sandy clay lenses, about	40
(Unconformity.)	
Basement rocks	
1. Decayed crystalline rock, apparently a gneiss, with quartz veins	3

On the Columbus-Cusseta road, one and one-half miles southeast of the bridge over Bull Creek, and about four and one-half to five miles southeast of Columbus (see topographic map, Columbus quadrangle), where the road leads up from the first Pleistocene terrace to the upland, the strata making up the hill are exposed, in part poorly, from the base to the top, making in all a thickness of about 140 feet. The lower 20 feet, consisting of coarse, cross-bedded, more or less arkosic sand, is referable to the Lower Cretaceous. The remainder of the section with the possible exception of the upper 18 feet, which may belong to a younger surficial formation, is classed with the Eutaw formation. The strata consists largely of sands and clays of marine origin. The contact between the Lower Cretaceous beds and the Eutaw formation is somewhat obscure owing to the resemblance of the sands of the former to the sands forming the basal beds of the latter. It is believed, however, that unconformable relations exist between the two divisions and that this unconformity represents an important time hiatus. (See detailed section, p. 124.)

Exposures of the formation were observed along the Steam Mill road running a little south of east of Columbus (first road south of the Buena Vista road, see topographic map of Columbus quadrangle), but most of these are small and unimportant. One, however, seven miles from Columbus, where the road passes up the westward facing slope of Tiger Creek Valley, presents phenomena of interest. The hill here is 100 feet high above the creek valley. The lower 80 feet of the section consists of light colored, coarse, irregularly bedded, arkosic sand, with subordinate light clay lenses. This is overlain, probably unconformably, by beds of the Eutaw formation which make up the upper 18 or 20 feet of the section. (See detailed section, p. 124.) The contact between the Lower Cretaceous strata and the Eutaw formation is rendered somewhat obscure by similarity of materials and weathering, but its approximate position is marked by an irregular line of iron crusts.

Other less conspicuous exposures of characteristic Lower Cretaceous materials were observed for several miles to the eastward along this road. On the divide between Steam Mill Creek and Wolf Creek there is a relatively thin capping of weathered marine materials of the Eutaw formation resting upon the Lower Cretaceous beds.

In the extreme northern part of Chattahoochee County the northward facing bluffs of Upatoi Creek exhibit Lower Cretaceous strata in their basal portions, their upper parts being made up of Eutaw beds. These were studied at three places as described below.

Just above the bridge of the Columbus-Lumpkin road, seven and one-half miles south of Columbus, the base of the bluff from the

water's edge to a height of 10 feet is composed of light gray, compact sands and clays, referable to the Lower Cretaceous. These are overlain by dark, calcareous marine sands and clays of the Eutaw formation. Although the latter formation is not marked at its base by a conglomerate the contact with the underlying formation is sharp, the change in the character of the materials being abrupt. It is believed that unconformable relations exist.

The second place examined is at a point one-quarter mile below the Columbus-Cusseta road bridge, and about seven miles southeast of Columbus. The bluff is 90 feet high. The upper 40 feet of the section consists of fossiliferous marine sands and clays of the Eutaw formation. Below this occur 20 feet of light gray, coarse, crossbedded, in places arkosic, sand, more or less streaked with yellow, with some sandy clay layers, referable to the Lower Cretaceous. At the time examined the basal 30 feet was covered by talus. The contact between the Lower Cretaceous and Eutaw formation was somewhat obscure owing to talus and vegetation. (See detailed section, p. 126.)

Just above McBride Ford, 11 miles south of east of Columbus, air-line distance, the creek bank presents another instructive section, the details of which are described below. (See also p. 127 of this report.)

Section, Upatoi Creek, just above McBride Ford, 11 miles south of east of Columbus, Ga.

	Feet
Pleistocene (terrace deposit).	
3. Principally sand with a gravel band along base	10 to 12
(Unconformity.)	
Upper Cretaceous	
Eutaw formation.	
2. Irregularly bedded, coarse, arkosic, crossbedded sand, with subordinate chocolate to black clay lenses. The sand is in places full of small angular quartz pebbles and some feldspar fragments, the basal portions being especially coarse. The materials contain considerable lignite, some of which is in the form of fairly large logs. The clay lenses contain leaf impressions, for the most part imperfect. In one dark clay lens, 6 to 10 inches thick, however, near the lower end of the bluff, a number of well preserved species were found	12 to 15
(Unconformity.)	
Lower Cretaceous	
1. Light gray, arkosic sand, and drab clay breaking with hackly fracture	0 to 5

The unconformity separating the Lower Cretaceous and Eutaw beds is fairly sharp and easily traceable for several hundred feet along the bluff, although the materials above and below the contact

do not differ markedly. The line of contact undulates along the face of the bluff, varying from low water level to five feet above that datum. The plants found in the clay lenses above the contact are characteristic Upper Cretaceous forms. A list of the species from this locality with the description of one new species has been published by E. W. Berry.[1] If the reference of the basal beds of the section to the Lower Cretaceous is correct the unconformity at this point represents an important time hiatus.

The Lower Cretaceous terrane is present in Talbot County in a belt paralleling the southern boundary of the county three to six miles in width. The formation rests unconformably upon a basement of crystalline rocks. The following log of a well located one-half mile east of Geneva has been obtained. J. F. Downs, the owner, is authority for the lithology.

Log of well located on "A very high elevated place 100 yards from Central of Georgia," Talbot County.

	Feet.
Lower Cretaceous	
1. Hard, red gravel with some "chalk" (white clay) and some sand, water-bearing in lower 5 feet	0 to 50

Veatch describes a section two miles southeast of Geneva in which the several strata of sand and clay are indurated. It is copied as follows: (Clay Report, p. 228.)

	Feet.
6. Clay	3
5. Soft sandstone	15
4. Jointed, purplish clay, indurated	6
3. Soft, yellow sandstone	20
2. Purplish, hard-jointed clay, with large quartz grains . . .	5
1. Soft, yellow, crossbedded sandstone	20

Veatch states that southward from the preceding, "The section is overlain by a loose, brown or yellow sand, belonging to the Upper Cretaceous (Eutaw)." (Clay Report, pp. 228-229.) He also says, "North and west of Geneva near the contact with the crystalline rock the material composing the Cretaceous is coarse and the clay is brilliantly colored by iron." (Clay Report, p. 229.) He mentions white sandy clays referable to this formation near Junction City. Beds of this formation are believed to be present along Juniper Creek in the extreme northern part of Marion County, but detailed information has not been obtained.

Lower Cretaceous beds are present in Taylor County in a belt several miles wide running east and west through the central part of the county. There is but little detailed information concerning individual outcrops. The formation rests with nonconformable rela-

[1]Bull. Torrey Botan. Club, No. 37, 1910, pp. 503-511.

tions upon crystalline basement rocks and is believed to be overlain unconformably by Upper Cretaceous sands and clays.

The following data are taken from Veatch's clay report. (pp. 223-224.)

"Sands of both the Upper and Lower Cretaceous occur in this county and are clay-bearing. The sands of the Lower Cretaceous are not easily distinguished from those of the Upper Cretaceous, and the white clays of both are similar in occurrence, but those in the vicinity of Butler, in the Tuscaloosa [Lower Cretaceous, but not Tuscaloosa] are purer and more extensive than elsewhere in the county.

"North of Butler the sand is noticeably coarser and more pebbly than south; there are beds of coarse, granular quartz pebbles and occasionally some feldspar pebbles; and at one point, a hard clay-arkose breccia, similar to that noted at Grovetown and Hephzibah, was found."

The log of an 80-foot well at Reynolds is given below. The description of the beds penetrated was furnished by the owner, A. J. Crawford.

Log of well located 600 yards southeast of the postoffice at Reynolds, Ga. Elevation at mouth, 433+ feet.

	Feet.	
Lower Cretaceous		
5. Sandy soil	1 to	4
4. Clay	4	11
3. "Chalk" (white clay) and clay	11	23
2. Coarse sand with some water at base	23	33
1. Alternating layers of clay, rock, and mud, furnishing a small amount of water at base	33	80

About the southern one-half of Crawford County is underlain by Lower Cretaceous strata, the belt of outcrop averaging four or five miles in width and extending in a general northeast-southwest direction. The lower and upper relations are the same as in the preceding county. Upper Cretaceous strata overlap the Lower Cretaceous beds in a strip several miles wide along the southeastern border of the county. There are several interesting exposures within this area.

Rich Hill is a prominent hill about five miles southeast of Roberta. Its elevation above sea level is estimated from aneroid readings to be something over 600 feet. Deep gullies have been washed in the slopes of the hill both on the north and south sides. Cretaceous beds make up the basal 30 feet of the exposed portion of the hill, the overlying beds constituting an Eocene outlier. The following section was made in one of the southward-facing gullies.

A. THOMAS BLUFF, CHATTAHOOCHEE RIVER, ONE MILE BELOW THE MOUTH OF BULL CREEK, MUSCOGEE COUNTY, GA., SHOWING LOWER CRETACEOUS STRATA.

B. EXPOSURE IN CUT OF COLUMBUS-MACON ROAD, THREE AND ONE-HALF MILES NORTHEAST OF COLUMBUS, GA., SHOWING INDURATED LAYER OF LOWER CRETACEOUS ARKOSE.

Section at Rich Hill, five miles southeast of Roberta. Gully on south slope of hill.

	Feet.	In
Eocene.		
3. Sand, clay and limestone. (For details see section, p. 299)	97	6
Lower Cretaceous		
2. White clay, varying in thickness and texture; very pure in places	10	
1. White, crossbedded, arkosic, micaceous sand, medium to coarse in texture, with subordinate lenses of white micaceous clay reaching 3 feet or more in thickness	20	

Cretaceous strata are exposed in a series of cuts of the Southern Railway from one-quarter mile to about one-mile north of Zenith Station. The details of this section are given on page 167. It will be observed that clay supposed to belong to the Lower Cretaceous appears in the base of the three cuts farthest north. This is overlain unconformably by coarse and fine sands and laminated clays of the Upper Cretaceous. The Lower Cretaceous clay is massive and putty-like when wet, and is usually light in color, but is considerably blotched with pink and purple tints. The correlation of this clay bed with the Lower Cretaceous is made on the grounds of its lithologic resemblance to the clays of that formation, and its unconformable relations with the overlying Upper Cretaceous sands and clays. Similar clays are exposed in a gully a short distance west of these cuts on the property of Phil Ogletree.

A well on the property of Phil Ogletree, one mile northwest of Zenith, exhibits the following strata, the owner being authority for the lithology as given.

Section of well one mile northwest of Zenith.

3. Red clay	?
2. White kaolin (clay)	?
1. Sand and gravel water-bearing	?
	45

The white clay and the water-bearing sand and gravel probably belong to the Lower Cretaceous.

A well owned by Isaac Miller, four and one-half miles northwest of Fort Valley, in Crawford County, having a depth of 103 feet, penetrated, at its base, three feet of white clay, which is questionably referred to the Lower Cretaceous. (See section p. 168.)

A well owned by Wm. J. Dent, one-quarter mile southwest of Roberta, is said by the owner to have been dug through hard clay with streaks of white "chalk" (clay) and to have obtained water from sand

beneath the clay at a depth of 42 feet. The beds penetrated should probably be referred to the Lower Cretaceous.

The Lower Cretaceous terrane is present over about the southeastern two-thirds of Bibb County, either at the surface or immediately beneath thin surficial deposits belonging to later formations. The formation rests upon crystalline rocks and is believed to be unconformably overlain along the southern border of the county by Upper Cretaceous sands and clays. An excellent exposure may be seen on the Central of Georgia Railway at Rutland, six and one-half miles south of Macon. The section is as follows:

Section at Rutland, Ga., in cut of Central of Georgia Railway.

	Feet.	
Pleistocene.		
4. Yellow, red, and mottled, weathered, sandy clay forming a fairly definite band along the top of the section. At south end of cut separated from underlying sand by iron crust one inch thick	5 to 7	
3. Coarse, pebbly, gray to red argillaceous sand with small lenses of pebbles, forming a fairly well defined band	5	6
2. Fairly well-defined band of yellowish and reddish gravel with coarse sand matrix and with interspersed lenses of coarse sand. Locally indurated to a conglomerate or coarse sandstone. The pebbles are mostly angular or slightly waterworn, and reach a maximum of 4 or 5 inches in diameter . .	6	10
(Undulating unconformity.)		
Lower Cretaceous		
1. Pale yellow or cream to almost white, massive finely arenaceous, micaceous clay, grading laterally at the north end of the cut into white or cream, cross-bedded coarse, extremely micaceous sand	3	8

Other cuts within one-half mile to the northward show materials with relations similar to the preceding. In a cut of the same railroad, four and one-half miles south of Macon, the following section is revealed.

Section in cut of Central of Georgia Railway, four and one-half miles south of Macon, Ga.

	Feet.	
Pleistocene.		
3. Coarse, yellow, rather loose sand	2 to 3	
2. Mottled red, yellow, and gray, very coarse, cross-bedded, pebbly sand with irregularly distributed gravel lenses. Pebbles mostly angular, some fairly well rounded, reaching a maximum of 3 or 4 inches in diameter	2	5
(Unconformity undulating 5 to 10 feet above base.)		
Lower Cretaceous		
1. Very coarse, cross-bedded, sharp, light gray, argillaceous sand streaked with yellow, with local lenses of white clay and scattered clay balls	5	10

One and one-half miles south of the station at Macon a cut of the Central of Georgia Railway reveals a section as described below:

Section at overhead bridge, Central of Georgia Railway, one and one-half miles south of Macon.

	Feet
Pleistocene.	
3. Reddish sandy clay	5
2. Mottled yellow and red, argillaceous sand with scattered pebbles at the top, becoming more pebbly and grading into a gravel bed with sand matrix at base. (Unconformity, slightly undulating)	5 to 6
Lower Cretaceous	
1. Cross-bedded arkosic; argillaceous sand	6 to 7

Exposures similar to the preceding occur for one-quarter mile north of the overhead bridge. Less important exposures of Lower Cretaceous strata occur at various places in the vicinity of Macon.

Otto Veatch furnishes the following information concerning occurrences of the formation in this county west of Ocmulgee River. (clay report, pp. 207-208.)

"At a point on the lower river public road, five miles below Macon, six feet of white clay is exposed in a cut. It is overlain by a red sand containing thin clay layers and fragments of white clay, and is underlain by white micaceous sand.

"In the western part of the county, along Echaconne Creek, beds of white clay will be found in the Cretaceous sands. But little or no prospecting for clay has been done in this part of the county, and but little is known concerning these deposits. Judging from the few observations made during field work, the beds are likely to be thin, and stained with iron oxide."

In the region to the southwest of Macon, there are remnants of overlapping strata, which are questionably referred to the Eocene.

Region between Ocmulgee and Savannah rivers.—Veatch gives the following information concerning the materials referable to the Lower Cretaceous in Bibb County east of Ocmulgee River: (clay report, p. 207.)

"In the cuts of the railroads, going east from Macon, good exposures of white clayey sands may be seen, but the amount of clay is small. * * * *."

"A typical occurrence of these clayey sands may be seen in the cut of the abandoned Macon and Augusta railroad, three miles east of Macon."

"At Brown Mountain in the southern part of the county, nine miles from Macon, 110 feet of white, clayey sand is exposed at the base of the hill. This sand is Cretaceous, (Tuscaloosa) [Lower Cretaceous and not Tuscaloosa] and contains thin layers and fragments or pellets of white, pure clay, but no thick beds of kaolin have been found. About two miles south of this point on the Tharpe estate, white clay has been found at the base of a fullers earth deposit, but as far as the writer knows no effort has been made to determine its quantity."

The greater part of Twiggs County is covered with deposits of Eocene age. However, in a small area in the western part of the

county the Lower Cretaceous strata come to the surface, and in the north, in what is known as the Dry Branch region, an interesting and economically important area of the formation has been produced by the removal of the overlying Eocene strata by stream erosion.

At the pit of the American Clay Company near Eleven Mile Post (east of Macon) the following succession of strata was observed:

Section at pit of American Clay Company, Eleven Mile Post, Ga.

	Feet.
Eocene.	
Claiborne group.	
2. Sand and clay (for details see section, p. 294) . .	28
(Unconformity.)	
Lower Cretaceous.	
1. White to very light gray, massive clay (used in the manufacture of paper)	18+

Veatch described the Cretaceous clay at this locality as follows:

"The clay is a soft, iron-stained kaolin, and is sold entirely to paper manufacturers.

"The clay bed is known to attain a thickness of 18 feet, the upper 10 feet of which is stained more or less yellow by iron oxide, while the lower part is a soft, gray, micaceous clay." (clay report, p. 138.)

The plant of the Atlanta Mining & Clay Company is located about one-half mile distant from the preceding locality, on the east side of the tracks of the Macon, Dublin & Savannah Railroad. This company is mining a bed of white clay which occupies the same, or approximately the same, stratigraphic position as the preceding. Veatch describes this clay as follows:

"A thickness of 25 feet of clay is known to occur, but at present only 8 to 15 feet are mined. The clay bed is for the most part a soft, plastic, white clay. The clay is massive and occurs in a single bed; it is jointed and shows slickensided surfaces, but presents no definite system of jointing, and is slightly stained by iron and manganese oxides along the joint planes. The bed shows variations in thickness, due either to irregularities of deposition or to erosion. The strata here are almost horizontal, and are but little disturbed from their original positions. The clays in the two pits, about 200 yards apart, are parts of the same bed. The clay bed becomes micaceous at the bottom, and is underlain by white sand and gravel.". (Clay Report, pp. 130-131.)

The Lower Cretaceous clay at this locality is overlain unconformably by Eocene strata. For a detailed section see page 294 of this report.

A bed of white clay or kaolin occupying approximately the same stratigraphic position as those previously described, is mined by the Georgia Kaolin Company, two miles southeast of Dry Branch. The following section describes the strata as they appeared at the time the pits were visited:

Section at pits of Georgia Kaolin Company, two miles southeast of Dry Branch.

	Feet.
Eocene.	
Claiborne group.	
2. Sands and clays (for details of section see p. 256)	131
(Unconformity.)	
Lower Cretaceous.	
1. Massive, white clay or kaolin	18

The unconformable contact separating the Cretaceous and Eocene strata at this locality is shown in the photograph, plate VI, A, opposite page 80.

Veatch describes the Lower Cretaceous clay bed at the preceding locality as follows:

"The clay mined occurs in one massive bed, which, in the pit that was being worked during 1907, attained a thickness of 20 feet. This entire thickness is probably as much as 85 per cent. pure clay, and in places the clay occurs in minable quantities as high as 98 per cent. pure without washing.

"The clay, as it appears in the bed and in the moist condition, is a drab or cream color, but becomes white when dry. The bed is jointed throughout. and presents slickensided surfaces along the joint planes. The clay in the upper part of the bed is a semi-hard to a flint clay, and may be stained slightly along the joint planes by manganese and iron oxides. The manganese is rarely in appreciable quantity and occurs as a very thin coating or stain, or is often in the form of fern-like dendrites. In the upper part of the bed there are also curious "fingers" and cylinders of sand, penetrating the white clay. This is a phenomenon observed nowhere else in the Dry Branch region, and is difficult of explanation. The "fingers" of sand are usually vertical or oblique, and are not more than one or two inches in diameter. The sand in them is a yellow, coarse quartz, clayey sand, which may be calcareous, and has been observed to contain poorly preserved fossil remains. These "fingers" are not large nor very abundant, but detract from the value of the clay where they occur and the upper part of the bed is thrown away as waste, or sold as fire clay and sagger clay. They are confined to the upper two or three feet of the bed, and are probably purely local and may not be found at all in future work.

"The lower part of the bed is a soft, white, gritless kaolin which is pure enough to place on the market without preliminary washing."—(clay report, pp. 125-126.)

Slight movement along joints in the clay at the preceding locality has been noted by Veatch.

The following data concerning other localities where the formation has been observed in Twiggs County have been abstracted (not quoted) from Veatch's clay report and from his unpublished notes: (pp. 142-143, 146-147, 149-152.)

On the property of I. Mandle and Company, two miles south of Dry Branch, 10 feet of white, semi-hard, high grade pottery clay is exposed in a pit at the company's mines. The clay bed is reported to have a total thickness of 15 feet. It is overlain by (Eocene) sand and clay. The relation of the clay bed to the overburden is shown in the following sections:

Section in clay pit of I. Mandle and Company, two and one-half miles south of Dry Branch, Ga.

	Feet.
Eocene.	
4. Red sand, about	8
3. Drab laminated clay, about	2
2. Gray and yellow sand with white clay fragments near base. Fossiliferous.	5 to 10
(Unconformity.)	
Lower Cretaceous.	
1. White, semi-hard, jointed clay	10 to 15

At the pit of the old Rico Kaolin Mine, one and one-half miles east of Philips Station, a white Cretaceous clay bed with relations as shown in the following section is exposed:

Section at old Rico Kaolin Mine, one and one-half miles east of Philips Station.

	Feet.
Eocene.	
Claiborne group.	
2. Red sand, containing white clay fragments and fragments of clay having a concretionary or bauxitic appearance	8 to 10
(Unconformity.)	
Lower Cretaceous.	
1. White clay, micaceous in the upper 8 feet with a micaceous, argillaceous sand lens several feet thick at one end of the section	16

In the vicinity of Bond's store (Delzell P. O.) there are numerous occurrences of white clays, the beds ranging in thickness from 10 to 30 feet.

Four feet of bluish white, plastic clay was encountered in a well on the property of Monroe Phillips at Reids Station, the bed being 18 feet below the surface. This probably belongs to the Lower Cretaceous.

Twelve feet of light, cream-colored clay, probably referable to this formation, outcrops on the property of Mrs. S. Napier, one-half mile south of Myrick Mill, five miles north of Jeffersonville.

For further information concerning the Dry Branch region see Veatch's paper, "The Kaolins of the Dry Branch Region, Georgia," Economic Geology, Vol. 3, 1908, pp. 109-117.

The Lower Cretaceous terrane is present in the southeastern one-fourth of Jones County. It rests upon a foundation of ancient crystalline rocks and is overlain unconformably over a part of the area by Eocene strata (Claiborne group).

Veatch, in his clay report, has described Lower Cretaceous strata near Griswoldville, on the property of J. R. Van Buren (pp. 153-158). The substance of the geological data in this account is given in the following three paragraphs:

The main exposure is in a cut of the Central of Georgia Railway one and one-quarter miles west of the station. This cut is 200 yards long and 40 feet deep. The materials consist of irregularly bedded, gray, arkosic and micaceous sands, and white, drab, and bluish gray clays. The clay beds are in the form

of lenses six to ten feet in thickness. Towards the east end of the cut the Lower Cretaceous beds are overlain with apparent unconformity by red sands, believed to be referable to the Eocene (Claiborne group).

In a cut three miles west of the station a white clay bed four to ten feet thick is exposed for a distance of 500 yards. A similar white clay bed eight feet thick is exposed one-quarter of a mile south of the Van Buren property.

In the vicinity of Roberts Station, gray, micaceous, kaolinic sand of the Lower Cretaceous occurs resting unconformably upon decomposed crystalline rocks and overlain unconformably by sands and clays, in part fossiliferous, of Eocene age (Claiborne group). These Eocene beds have been traced southeastward, capping a Cretaceous ridge, to the cut one and one-quarter miles west of Griswoldville, above described.—(See p. 282 of this report.)

Mr. J. R. Van Buren is authority for the lithology as described in the following log of a well on the property of the J. R. Van Buren Company, one mile north of Griswoldville:

Log of well one mile north of Griswoldville, Ga.

Lower Cretaceous	Feet.	
5. Sand, about	0	8
4. White clay		?
3. Red clay		?
2. Sand, water-bearing, about	?	78
1. White clay, about	78	84

Lower Cretaceous strata underlie practically all of Wilkinson County. Over a large part of the county, however, the Lower Cretaceous beds are overlain unconformably by Eocene strata. Porters Creek, Commissioners Creek, and Oconee River have cut through the Eocene deposits, bringing the Lower Cretaceous to the surface along the sides and bottoms of their valleys. The Eocene beds reach a thickness of 135 feet or more on the intervening divides.

The following data concerning occurrences of the formation in this county have been abstracted (not quoted) from Veatch's clay report, pp. 159-172:

On the property of J. W. Huckobee one mile west of Lewiston, near the Central of Georgia Railway, a white clay bed three to twelve feet in thickness has been mined to a limited extent. The clay is overlain by ten to twenty feet of sands and fossiliferous, siliceous beds resembling quartzite of Eocene age (Claiborne group).

On the Z. T. Miller place, three miles south of Gordon, a 30-foot bed of white clay appears in a natural exposure. This bed which belongs to the Lower Cretaceous is overlain by tough, plastic, impure clays and red sands referable to the Eocene (Claiborne group). There are a number of other localities in the vicinity of Gordon where similar white clays outcrop beneath sands and clays of the Claiborne group, the latter exceeding a thickness of 100 feet in places.—(See detailed sections on pp. 276-277 of this report.)

White clays occur at a number of localities in the vicinity of McIntyre. Three miles east of this place there are natural exposures of white clay, four to twelve feet thick, overlain by 30 to 50 feet of red sands and impure clays of the Claiborne group.

A bed of semi-hard white clay reaching a maximum thickness of 30 feet outcrops on the Hatfield property one and one-half miles west of McIntyre,

on the south side of the Central of Georgia Railway track. The exposure occurs at the base of a ridge, the overlying strata consisting of Eocene (Claiborne) sands and clays.

Three miles northwest of McIntyre, on the property of Robert Billion, 12 feet of soft, white and cream-colored kaolin outcrops in a deep gully, opposite the residence of William Snow, beneath 40 feet of Eocene sands and clays (Claiborne group).

On the George Bentley property, two and one-half miles north of the 159th mile post of the Central of Georgia Railway, 12 to 15 feet of white and cream-colored clay is exposed in a roadside gully.

White clay beds occur in the region immediately to the north of Toomsboro, and in a cut of the Central of Georgia Railway at Beech Hill, four miles east of Toomsboro.

Veatch furnishes the following unpublished note on occurrences of Lower Cretaceous clays in the vicinity of Irwinton:

"Irwinton is situated on a high Tertiary ridge capped with red sand. The Cretaceous is exposed in the valleys 150 to 200 feet lower.

"On the Tolar place, four miles south of Irwinton, and on Big Sandy Creek, hard white clay, 20 feet thick, is overlain by Tertiary clay. On the basis of this white clay bed the Cretaceous is mapped along Big Sandy Creek almost to Stephensville.

"There is a suggestion that there is one continuous bed of white clay underlying a large area in Wilkinson and Twiggs counties. This clay bed, which is known to reach a thickness of 30 feet or more, has been observed at a number of localities to the north and west. It is characterized by its purity, freedom from any large amount of sand, absence of bedding or lamination, and absence of anything that suggests marine conditions. With the possible exception of South Carolina, these heavy white clay beds have no counterpart in any other portion of the United States."

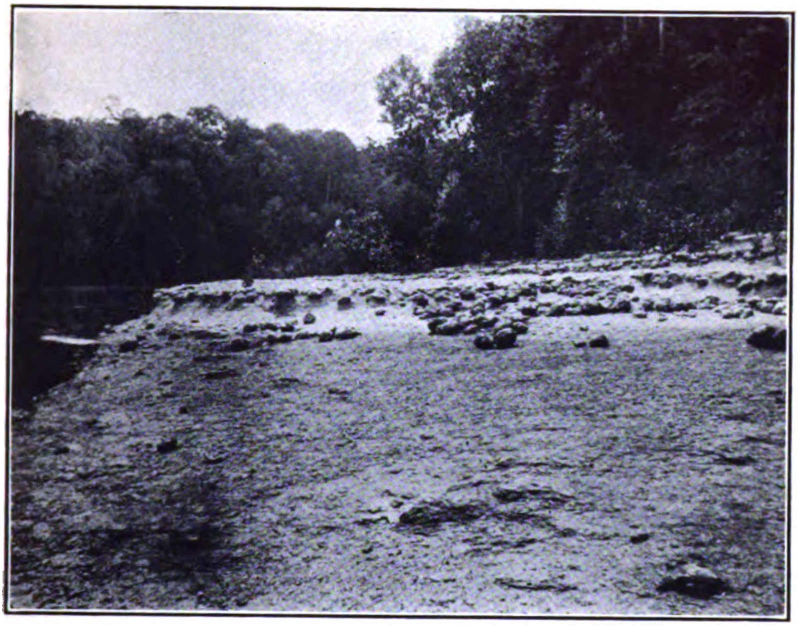
One-half mile west of Irwinton the following section of a well on the property of D. H. Howell was obtained, the authority for the lithology being the owner:

Section of well located at foot of high hill.

		Feet.	
Lower Cretaceous.			
3. Clay	about	0	18
2. Kaolin	about	18	53
1. Layer of rock, water from beneath rock		53	59

At nearly all of the localities described on preceding pages the Lower Cretaceous sands and clays are overlain unconformably by sands and clays of Eocene age (Claiborne group). (See detailed sections of Eocene strata in Wilkinson County on pp. 276-278 of this report.)

Locally the white, Lower Cretaceous clays of Wilkinson County have been altered to bauxite. The known bauxite occurrences have been studied by Otto Veatch, and have been treated in some detail by him in his clay report. (Appendix D, pp. 430-447.) The bauxite, so far as discovered, occurs at the top of the Lower Cretaceous terrane



A. EXPOSURE ON RIGHT BANK OF CHATTAHOOCHEE RIVER AT BROKEN ARROW BEND, TEN AND ONE-HALF MILES BELOW COLUMBUS, GA., SHOWING LAYERS OF NODULAR, CALCAREOUS CONCRETIONS IN BASAL, MARINE BEDS OF THE EUTAW FORMATION.

B. EXPOSURE IN CUT OF STEAM MILL ROAD, SEVEN MILES EAST OF COLUMBUS, GA., SHOWING PECULIAR SHORT, THICK LENSES OR SEGREGATIONS OF WHITE SAND IN MATRIX OF GREENISH, FOSSILIFEROUS SAND NEAR BASE OF EUTAW FORMATION.

immediately beneath its contact with overlying Eocene sands and clays.

The principal localities where the ore has been found are in the vicinity of Toomsboro, Irwinton, McIntyre, Gordon, and Cooper Station.

Portions of the southern and eastern parts of Baldwin County are underlain by Lower Cretaceous strata. The beds rest upon crystalline basement rocks and are overlain in a limited area in the vicinity of Stevens Pottery by overlapping Eocene beds. The best known occurrences are at Stevens Pottery, eight and one-half miles south of Milledgeville, where they are many good exposures. These show a great horizontal variation in the character of the materials. The following section describes the several strata as they appeared in the main pit east of the railroad at the time examined:

Section in main pit at Stevens Pottery, Ga.

	Feet.
Eocene.	
4. Red, argillaceous sand, mottled in places	4 to 5
(Unconformity.)	
3. Mottled pinkish and yellowish, argillaceous sand and sandy clay	10 to 15
2. Red, crossbedded, ferruginous sand containing along base a few quartz pebbles and white siliceous clay pebbles	12 to 15
(Unconformity.)	
Lower Cretaceous.	
1. White, more or less sandy, massive clay, used principally in the manufacture of fire brick, sewer pipe, etc.	10

In an abandoned pit on the west side of the railroad track the following section was made:

Section in abandoned pit, west side of railroad track, Stevens Pottery, Ga.

	Feet.
Eocene.	
2. Coarse, yellowish and gray, arkosic, crossbedded sand, with boulders along base consisting of white clay pellets in a darker drab clay matrix. There are also along the base white, rounded, silicified clay pebbles and some quartz, garnet and hornblende pebbles	8
(Unconformity.)	
Lower Cretaceous.	
1. Light to white, arkosic sands with lenses up to six or eight feet in thickness, of white clay, more or less sandy and micaceous. Locally, especially near base, there are irregular iron concretions	20

About one-quarter mile south of the station at Stevens Pottery, on the west side of the railroad track, the Lower Cretaceous arkosic sands and white clays are seen to be overlain by markedly unconformable olive-green, harsh, siliceous, and probably calcareous clay, which is certainly referable to the Eocene (Claiborne). Along the base of this green clay are numerous pebbles of quartz, silicified clay, garnet, and hornblende, and small boulders of pisolitic clay.

Veatch, in his clay report, has described the clays at Stevens Pottery from the standpoint of their economic value (pp. 172-174).

A well drilled at this place passed through the Lower Cretaceous beds and entered the underlying basement crystallines at a depth of about 75 feet beneath the surface. The latter, consisting of a decomposed granite rock, was penetrated to a depth of 175 feet. The authority for this data is W. C. Stevens, of Stevens Pottery, Ga.

One and one-half miles a little south of east of Milledgeville, a few feet of coarse, cross-bedded, arkosic sand was observed in a road-cut on a hill slope, resting in a shallow depression in deeply decayed crystalline rocks which compose the body of the hill to its summit. The hill is about 125 feet high and the sand deposit is well down toward its base. This bed is believed to be a Lower Cretaceous remnant. Overlying the sand with apparent unconformity is a surficial covering, three or four feet thick, of coarse sands and gravels of uncertain age.

Lower Cretaceous strata have a limited areal distribution in the western and northern parts of Washington County. They are overlain by Eocene strata and would not appear at the surface were it not for the erosion which has produced the valleys of Oconee River, Buffalo Creek, and Ogeechee River.

Veatch has noted a number of occurrences of the formation in this county. The following data has been adapted (not quoted) from his clay report, pp. 176-179, and from pp. 274-276 of the present report:

Ten miles north of Oconee on the property of Mrs. S. M. Gilmore, 15 feet of white clay is overlain by 20 or 30 feet of red mottled sand.

Six miles west of Sandersville, on the upper Milledgeville Road where it descends to Keg Creek, 16 feet of hard, massive, white fire-clay of Lower Cretaceous age is overlain unconformably by 125 feet of Eocene sands and clays.

At the old Carter Mill site, five and one-half miles north of Sandersville, six feet of massive, white fire-clay outcrops beneath Eocene sands and clays; and one mile north of this mill there is an outcrop of 12 feet of massive, white fire-clay showing similar relations to the Eocene sands and clays above. This clay bed is underlain by typical Lower Cretaceous sands.

On the road to Hebron, seven miles southwest of Sandersville, four feet of white clay outcrops at the base of a hill beneath 90 feet of Eocene sands and clays. The same relations were observed in a cut two miles southwest of Chalker.

One mile south of Chalker on the public road, white and yellow sands referable to the Lower Cretaceous are overlain by 80 feet of Eocene sands and clays.

Lower Cretaceous sediments are present over much of the southern half of Hancock County. The total thickness of the beds is not great since the basement rocks upon which they rest appear in the valley bottoms of many of the streams. In limited areas in the southeastern part of the county overlapping Eocene strata rest upon the Lower Cretaceous beds.

The best exposures of the formation in Hancock County are in the first two cuts of the Georgia Railroad, a short distance southwest of Carrs Station. At several places the contact with the underlying basement rocks, which consist of deeply decayed granite and schist, is visible. The line of contact is very uneven, varying from below the level of the track to a maximum of 12 feet above that datum. The maximum thickness of materials exposed is 50 or 60 feet. The Lower Cretaceous materials consist of light-colored, coarse, cross-bedded, arkosic sands with interstratified lenses of light to white clays, the latter reaching a maximum thickness of 10 or 12 feet, and with clay boulders and clay balls scattered somewhat irregularly through the sands. The most prominent lens of white clay is at the north end of the first cut. This bed has a maximum thickness of 10 or 12 feet, but is replaced by sand a short distance away laterally. Near the base of this lens and about eight feet above the track level, a few, faint, indeterminable leaf impressions were observed in soft, mealy, laminated clay. This is the only known occurrence of leaf remains in this formation in Georgia. In the second cut there is a very conspicuous unconformity, 30 to 40 feet above the track level, probably local within the Lower Cretaceous strata. The materials above this unconformity consist of coarse, yellow, cross-bedded sands with gravelly layers near the base, the whole presenting a darker appearance than those beneath. A similar unconformity may also be seen at one place in the first cut; here above the contact, in the base of the overlying darker sands there are large boulders of white clay. In both cuts a few feet of loose, gray, surficial sands overlie the older materials. This locality has been described by Veatch in his clay report (pp. 204, 205, Pl. 13, Figs. 1 and 2).

Lower Cretaceous strata underlie practically all of Glascock County. The formation is underlain by crystalline basement rocks which are exposed in stream beds at a few places in the northern part of the county, and also at one or two places near the center of the county. It is overlain over much of the area by beds of Eocene age.

The following data relating to this county have been abstracted

(not quoted) in part from Veatch's clay report (pp. 180, 181), and in part from his unpublished notes. (See also pp. 273-274 of this report.)

On the J. Newsome property, three miles east of Gibson, on the roadway leading from Deep Creek to the Newsome residence, is an outcrop of white clay or kaolin which has an overburden of some 75 feet of Eocene sand, clay, and limestone. Borings to determine the extent of the kaolin bed showed an average thickness of 23 feet in a linear distance of 200 yards.

At Jumping Gully Creek on the Gibson-Mitchell road, one mile west of Gibson, ten feet of white clay underlies unconformably 23 feet of sand and clay of Eocene age.

Four miles south of Gibson, at Tompkins Ford, Joes Creek, on the Grange Road, 15 feet of white, massive, semi-indurated clay occupies an unconformable position beneath about 50 feet of clay, sand, and quartzite of Eocene age. Beneath the white clay bed is a soft clay and sand conglomerate.

Twelve feet of white Lower Cretaceous clay occurs on the property of J. T. Brady, two miles south of Agricola, and ten feet of similar clay on Big Creek four miles southeast of Agricola.

Exposures of granite rock occur on Joes Creek, two miles south of Beall Spring Station, and also two and one-half miles north of Mitchell.

There are a few small areas in the western part of Jefferson County, on Ogeechee River and Rocky Comfort Creek, where Lower Cretaceous strata probably appear at the surface, but detailed information is lacking.

J. W. Stapleton, of Wrens, Ga., reports that in a well owned by him, located four miles northwest of Wrens, white clay was penetrated from 38 to 48 feet beneath the surface. Water was obtained in white gravel and quicksand immediately beneath the clay. It is probable that the clay and the water-bearing materials immediately beneath the clay belong to the Lower Cretaceous.

Prof. S. W. McCallie[1] has published the record of a well located three and one-half miles southwest of Louisville, having a depth of 1,143 feet. Eocene beds were penetrated to a depth of 350 feet. Basement rock, consisting of hard, diorite schist was penetrated in the lower three feet. The materials from 350 to 1,140 feet, consisting of sand, clay, and hard rock, are probably of Cretaceous age, but whether this whole thickness—790 feet—belongs to the Lower Cretaceous, or whether a part of the upper portion should be referred to the Upper Cretaceous can not be determined from the available data. No Upper Cretaceous strata are known at the surface nearer than Aiken County, S. C., on the one hand, and western Twiggs County, Ga., on the other, but it does not seem improbable that beds of this age exist in this intervening region, buried beneath the overlapping Tertiary covering.

Lower Cretaceous strata underlie portions of southern Warren

[1]Geol. Survey of Georgia, Bull. No. 15, 1908, pp. 128-131.

County. The beds rest unconformably upon the uneven surface of the basement crystalline rocks, which appear at the surface in all the stream valleys. The total thickness of the terrane within the county limits is not great.

Light-colored sands and coarse gravels referable to the formation are well exposed in cuts of the Georgia Railroad, three or four miles southwest of Warrenton. They rest unconformably upon deeply decayed crystalline rocks.

Veatch, in unpublished notes, has described a supposed occurrence of the formation on the Georgia Railroad, three miles northwest of Norwood. The materials consist of red, pebbly sand and loam, 15 feet in thickness, resting upon deeply decayed, crystalline schist. The pebbles are for the most part subangular quartz up to three or four inches in diameter, with a small percentage well rounded. Cross-bedding was observed at one place. The deposit is believed to be an isolated remnant of Lower Cretaceous strata. Veatch also notes a deposit of coarse sand and angular gravel probably belonging to this formation at Beall Spring, eight miles southwest of Warrenton.

The Lower Cretaceous terrane is present over the greater part of McDuffie County south of the Georgia Railroad, and there are a few small areas extending north of the railroad. The beds rest upon crystalline basement rocks. In the southern part of the county the Lower Cretaceous strata are overlain in disconnected areas by Eocene sediments. Streams have cut through the beds at many places, revealing the underlying crystalline rocks.

Materials referable to the formation are noted by Veatch in his clay report (pp. 200-203, abstracted, not quoted), at the following places in this county:

One mile east of Thomson on the Shields property a bed of white clay ten feet thick is reported.

On the Brinkley plantation, three miles southwest of Dearing, 16 feet of white kaolin blotched with purplish or pink iron stain, is reported to have been penetrated in a well.

Three miles west of Dearing, on the Milledgeville public road, a bed of plastic, white clay occurs at a point locally known as "Chalk Hill". About one-half mile west of this locality 30 feet of white clay is reported to have been penetrated in a well, the top of the clay bed having been encountered 30 feet below the surface.

Exposures of Lower Cretaceous clay are numerous throughout the southeastern part of the county along Boggy Gut, Headstall, and Brier Creeks. Especial note is made of such clays on the T. J. Connell and J. F. Whitaker properties, four and one-half miles south of Harlem.

Veatch also furnishes the following unpublished notes:

"At mile-post 34, near Boneville, the base of the Lower Cretaceous consists of coarse sand containing clay and sub-angular quartz gravel. Fragments of vein quartz as much as two feet long were observed. A biotite

granite is exposed in a small stream one-half mile east of this locality. The Lower Cretaceous strata at Boneville is not more than 40 feet thick, according to a well record.

"On the property of Thomas Jefferson, two and one-half miles southeast of Dearing, eight feet of white and stained clay underlies unconformably 20 or 30 feet of laminated clay, probably of Eocene age."

Lower Cretaceous strata are present in the southern part of Columbia County in limited areas in the vicinity of Harlem, Berzelia, and Grovetown. They rest unconformably upon crystalline basement rocks and are overlain in part by overlapping Eocene strata which in places transgress northward entirely across the Lower Cretaceous beds and rest upon the crystallines.

There are good exposures of arkosic sands and white and purplish clays referable to this formation in cuts one to two miles east of the station at Grovetown. Although the contact does not appear in the railroad cuts, other exposures in the vicinity of Grovetown show the Lower Cretaceous strata to be overlain unconformably by fullers earth clay of Eocene age. This relation is well exhibited in what is known as Phinizy Gully, about one mile east of Grovetown, on the old abandoned Augusta to Wrightsboro wagon road. The following sketch shows the profound character of the unconformity.

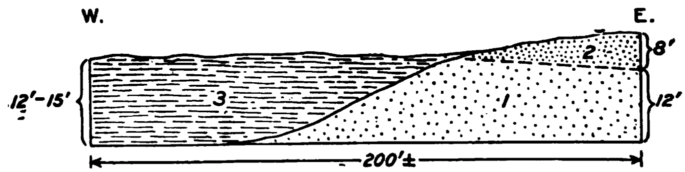


Fig. 8. Sketch showing relation of Cretaceous and Eocene strata at Phinizy Gully, near Grovetown, Ga.

Explanation of sketch.

	Feet.
Eocene.	
3. Shaly fullers earth clay with fine sand partings. Contains leaf impressions and casts of pelecypods	12 to 15
(Unconformity.)	
Lower Cretaceous.	
2. Coarse, gray, argillaceous sandstone	8
1. Coarse, arkosic sand	12

The following references to Lower Cretaceous beds in this county are abstracted (not quoted) from Veatch's clay report, pp. 196-200:

At the works of the Georgia Vitrified Brick & Clay Company, at Campania, one and one-half miles east of Harlem, 12 feet of white clay is exposed in a pit 100 yards northeast of the plant. As shown by other pits nearby this clay is overlain by 25 feet or more of clay and sand referable to the Eocene, (Claiborne).—(See detailed section, p. 271 of this report.)

In the old fullers earth pit on the Fiske property at Grovetown, 3 or 4 feet of white clay makes up the base of the section. It is overlain by Eocene fullers earth.—(See p. 269 of this report.)

At Phillips Falls, one and one-half miles southwest of Harlem, ten feet of massive gray to bluish gray, hard clay is overlain by about 40 feet of Eocene sands and clays. The clay is underlain by Lower Cretaceous sand containing large chunks of kaolin and disseminated kaolin grains.—(See detailed section on p. 271 of this report.)

In unpublished notes Veatch describes Lower Cretaceous beds at the following additional localities in this county:

"One-half mile west of the section foreman's house at Forest, eight to ten feet of arkose is exposed overlain by Eocene fullers earth.

"Near the 17-mile post, two miles south of Grovetown, four or five feet of white clay presumably of Lower Cretaceous age is superimposed by red and yellow sands probably of Eocene age.

"On the H. Merry place, four and one-half miles southwest of Berzelia, on Sandy Run Creek, ten feet or more of Lower Cretaceous clay and sand was observed beneath 90 feet of Eocene sands and clays.—(See detailed section p. 291 of this report.)

At the lignite pit of the Georgia Lignite Mining Company, three miles south of Grovetown, coarse quartz sand containing white clay was encountered at the bottom of a shaft beneath the lignite. The coarse sands are referred to the Lower Cretaceous, while the overlying lignites are believed to belong to Eocene.—(See detailed section, p. 270 of this report.)

Coastal Plain deposits cover all of Richmond County except a small area in the extreme north. Lower Cretaceous strata outcrop in a belt several miles wide extending from Augusta and south of Augusta westward to the county line, and also farther south in the county along the valley of Spirit Creek. The formation rests unconformably upon crystalline rocks which outcrop in the northern part of the county. The Lower Cretaceous beds pass to the southward beneath overlapping Eocene strata, the latter covering nearly all of the southern part of the county. There is also a long, narrow area of Eocene strata capping the ridge between Butlers and Spirit creeks, and extending northwestward to Grovetown in Columbia County.

The hills to the west and southwest of Augusta, with the exception of their surficial deposits of sandy clays, sands, and gravels, are made up of Lower Cretaceous beds. The materials consist of characteristic, coarse, arkosic, argillaceous sands with subordinate lenses of clay. The strata are for the most part concealed by coarse, surficial gravels and red sands which cover the tops and slopes of the hills. The age of the latter has not been satisfactorily determined, but they may be Eocene. In the cuts of the Georgia Railroad between Augusta and Grovetown there are numerous exposures of coarse, cross-bedded, arkosic sands, containing in places pellets and boulders of white clay and occasional lenses, which are referable to the Lower Cretaceous.

A well, 144 feet deep, located on the property of R. T. Ulm, two miles north of Debruce, is said by the owner to have passed through sand to a depth of 140 feet, below which clay was penetrated to a depth of four feet. The section is probably all referable to the Lower

Cretaceous, although a small thickness of Eocene strata may compose the upper portion.

The following data concerning the occurrence of the formation in this area have been abstracted (not quoted) from Veatch's clay report, pp. 185-196, and from his unpublished notes:

In the vicinity of Belair a small thickness of Lower Cretaceous strata is present. The beds rest upon the upturned edges of metamorphic schists. The materials consist of gray or white sands containing clay pellets with interbedded, thin, white clay layers.

One and one-quarter miles east of Belair at the eight-mile post, a cut of the Georgia Railroad exhibits the following section:

Section at the eight-mile post, Georgia Railroad, Richmond, County, Ga.

		Feet.
Lower Cretaceous.		
3.	Strongly crossbedded sand with soft, white clay pebbles one to two inches in diameter, and scattered quartz pebbles	7 to 10
	(Local unconformity.)	
2.	White and stained clay	0 to 4
1.	Gray and white, unconsolidated, arkosic sand . .	4
	Total	18

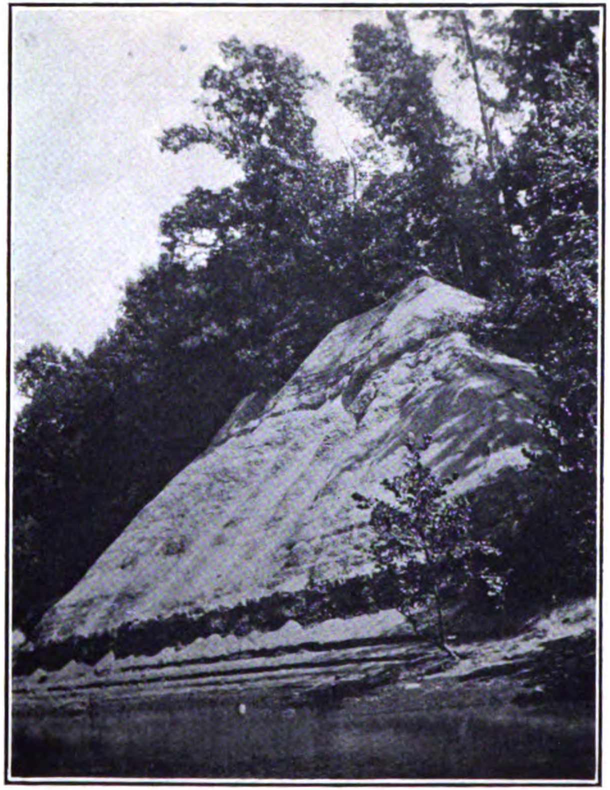
On the Milledgeville road, five and one-half miles northwest of Augusta, at a place known as "The Rocks" an indurated arkose is exposed. The rock is a gray, arkosic sandstone, resembling decomposed granite, its sedimentary character not being readily recognized. It is composed of angular quartz, muscovite mica, and kaolin, with small amounts of magnetite and rutile recognizable only under the microscope. Hard, opaline silica is the cementing agent. A thickness of 15 feet was observed.

Section on the east side of a small stream on the King estate, two and one-half miles south of Belair, and five miles southeast of Grovetown. (Clay report, p. 192.)

		Feet.
5.	Slope covered by a mantle of loose sand	20
4.	Red and orange-colored loose sand	40
3.	Semi-indurated, massive bedded, white clay . . .	18
2.	Orange-colored sand, with pebbles and white clay layers	30
1.	Sand to creek, character concealed	50

Layer No. 4 is referable to the Eocene (Claiborne group), and layers Nos. 1, 2, and 3 to the Lower Cretaceous. A similar section occurs about one-half mile below the preceding.

On the old Blackstone place, one mile south of the 18-mile post on the Georgia Railroad, at a place known as O'Connor Hill, the following section occurs:



A. SLICK BLUFF, CHATTAHOOCHEE RIVER, RIGHT BANK, FOURTEEN MILES BELOW COLUMBUS, GA., SHOWING GREENISH GRAY CLAY OF THE EUTAW FORMATION.

B. SANDSTONE DIKE IN CLAY OF THE EUTAW FORMATION, AT SLICK BLUFF, CHATTAHOOCHEE RIVER, FOURTEEN MILES BELOW COLUMBUS, GA.

Section on Blackstone place, O'Connor Hill, one mile south of 18 milepost, Georgia Railroad.

		Feet.
Age?		
6.	Limonite fragments in sand	10
5.	Siliceous iron ore	2 to 4
4.	Gravel bed	3
Eocene (Claiborne group.)		
3.	Fine red and yellow sand with thin clay layers	50
	(Unconformity.)	
Lower Cretaceous.		
2.	Massive white clay	12
1.	Partly concealed, but consisting in part of white, micaceous, arkosic sand	40

A considerable thickness of hard, white, fire clay occurs along Sandy Run in the southwestern part of the county.

At Hephzibah the Lower Cretaceous is well exhibited in a pit of the Albion Kaolin Company. The section given below was made along the north side of the pit, but sections exposed in other parts of the diggings show the strata to be extremely variable in character horizontally. (See clay report pp. 186-188.)

Section on north side of pit of Albion Kaolin Company, Hephzibah, Ga.

		Feet.
Eocene (Claiborne group).		
5.	Bright red sand, estimated	40
4.	Shaly sandstone containing fossil leaves	4
Lower Cretaceous.		
3.	Semi-indurated, massive, white clay	3 to 20
2.	Crossbedded, arkosic, micaceous sand with white clay particles and pellets, locally indurated to sandstone	3 to 20
1.	Soft, white and cream-colored clay, reported thickness	9
	Total about	76

Savannah River.—No exposures of Lower Cretaceous strata occur in the immediate banks of the river at Augusta. However, a short distance northeast of the wagon bridge in Aiken County, S. C., the supposed base of the formation is seen, as described in the following section:

Section a short distance northeast of the wagon bridge leading from Augusta to Old Hamburg, Aiken County, S. C.

		Feet.
Lower Cretaceous.		
2.	Heavy bed of pebbles and cobbles of quartz and crystalline rock, angular to smoothly-rounded, in a matrix of sandy clay	4 to 8
	(Unconformity.)	
Basement rocks.		
1.	Decayed schist, about	20

The base of the section is about 40 feet above zero water level of the river.

The only place where the formation is exposed in the immediate bluffs of the river is at Sand Bar Ferry, about four miles below Augusta, in Aiken County, S. C.

Section at Sand Bar Ferry, four miles below Augusta, Ga., in Aiken County, S. C., left bank.

	Feet.
Pleistocene?	
4. Yellow, mottled, argillaceous, coarse sand	6
3. Medium to coarse, light gray and yellow micaceous, argillaceous sand with gravel lenses developed in the lower 10 feet	20
(Unconformity.)	
Lower Cretaceous.	
2. Coarse, arkosic, micaceous, argillaceous sand with small, white clay balls	25
1. Concealed to waters edge	10

The point at which the top of the Lower Cretaceous terrane passes beneath water level on the river can not be observed on account of the alluvial deposits through which the river flows below the last described bluff.

Wells south of the belt of outcrop.—South of the belt of outcrop of the Lower Cretaceous strata several wells have been drilled through the overlying Eocene beds into the Lower Cretaceous beds beneath. Logs of three such wells have been published by Prof. S. W. McCallie and are repeated here.

Log of well at Sandersville, Washington County, Ga., prepared from samples furnished by C. E. Warthen.

		Feet.
12.	White and dark clays with pyrite.	at 35
11.	White, sandy limestone	" 85
10.	Gray limestone, with fragments of shells	" 103
9.	Dark clay	" 160
8.	Yellow, coarse sand	" 215
7.	White kaolin	" 270
6.	Fine white sand	" 285
5.	Dark, pyritiferous sand	" 335
4.	White kaolin	" 370
3.	Rather coarse brownish sand	" 387
2.	White sand	" 426
1.	Fine white sand	" 436

The upper four layers in the above described well at 35, 85, 103, and 160 feet, respectively, are believed to belong to the Eocene, and the remainder of the strata to the Lower Cretaceous.

[1]Bull. Geol. Survey of Georgia, No. 15, 1908, p. 186.

Log[1] of well at Tennille, Washington County, Ga., copied from the notes of the well contractor.

		Feet.	
25.	Sandy clay	0	38
24.	White clay	38	52
23.	Yellow sandy clay	52	80
22.	White sand	80	91
21.	Yellowish limestone, in the form of boulders	91	96
20.	Gray sand	96	103
19.	White sand	103	130
18.	White sandstone containing shells	130	140
17.	Bluish marl	140	185
16.	Yellow clay	185	194
15.	Brownish colored sand, containing sharks' teeth and fragments of oyster shells	194	210
14.	Blue marl	210	260
13.	Quicksand	260	270
12.	Blue marl	270	300
11.	White clay	300	310
10.	Blue clay	310	350
9.	Blue and gray sands	350	360
8.	Blue clay	360	404
7.	Quicksand	404	436
6.	White clay and sand	436	440
5.	Coarse white sand	440	470
4.	White "sticky" clay	470	500
3.	Red clay	500	530
2.	White clay	530	550
1.	Clay and sand, except at 820 feet, where sandstone occurs	550	990

The strata from the surface to a depth of 300 feet in the above described well probably belong to the Eocene; the remainder of the beds are believed to be of Lower Cretaceous age.

A portion of the log[2] of an oil-prospecting well, three and one-half miles southwest of Louisville, Jefferson County, Ga., furnished by the contractor, Mr. James Tague.

		Feet.	
46.	Sand	307	505
45.	Red clay	505	510
44.	Red and white clay	510	532
43.	Red clay	532	562
42.	Sand	562	581
41.	White clay	581	583
40.	Hard clay	583	584
39.	Clay	584	588
38.	Sand with gas	588	599
37.	Sand with hard layers	599	661
36.	Mixed clay	661	665
35.	Sand	665	704
34.	Mixed clay	704	741
33.	Sand	741	751

[1]Op. cit., pp. 187, 188.
[2]Op. cit. pp. 128-131.

32.	Clay	751	759
31.	Sand	759	775
30.	Tough clay	775	783
29.	Sand	783	793
28.	Hard layer	793	798
27.	Sand	798	800
26.	Sandy clay	800	843
25.	Sand	843	853
24.	Mixed clay	853	870
23.	Sand	870	896
22.	Mixed clays	896	913
21.	Sand	913	929
20.	Clay	929	948
19.	White and yellow sand	948	955
18.	White clay	955	965
17.	Sand	965	976
16.	Shale	976	979
15.	Clay	979	999
14.	Sand	999	1001
13.	Clay	1001	1006
12.	Hard layer	1006	1006
11.	Blue clay	1006	1027
10.	Sand	1027	1035
9.	Clay	1035	1052
8.	Sand	1052	1058
7.	Shale	1058	1062
6.	Sand	1062	1068
5.	Clay	1068	1088
4.	Clay and shale	1088	1111
3.	Very hard shale	1111	1113
2.	Cemented gravel	1113	1140
1.	Hard rock	1140	1143

Fossils characteristic of the Claiborne group of the Eocene were obtained from the preceding well at a depth of 250 feet. A fragment of a turtle plate, supposed to be referable to the Upper Cretaceous, was obtained at a depth of 380 feet. On the basis of these fossils the contact between the Cretaceous and Eocene is believed to be somewhere between the depths indicated, and it is here placed tentatively at 350 feet. Crystalline basement rocks were encountered at 1,140 feet. The probable total thickness of Cretaceous strata penetrated is, therefore, 790 feet.

The data obtained from this well were insufficient to permit distinguishing between Upper and Lower Cretaceous strata, but it is believed that beds of both ages are represented. Doubtless the lower 500 or 600 feet of the Cretaceous portion of the section should be referred to the Lower Cretaceous and the remainder to the Upper Cretaceous, probably to the Ripley formation.

CORRELATION

The basal portion of the Cretaceous deposits of the Coastal Plain in the region included between Alabama Valley in Alabama and the

Roanoke Valley, in North Carolina is composed of highly cross-bedded, arkosic sands, in general of coarse texture, with subordinate, inter-bedded layers and lenses of light-colored clays of greater or lesser purity, reaching an estimated maximum thickness of 500 or 600 feet. These have been erroneously regarded as the eastward continuation of the Tuscaloosa formation by the Alabama and Georgia geologist.[1, 2] They have been designated the "Hamburg beds" by Earle Sloan[3] in South Carolina, and the "Cape Fear" formation by the writer[4] in North Carolina.

In the Carolinas these beds are separated from the overlying Black Creek formation by an unconformity. Likewise an unconformity separates them from the overlying Eutaw formation in the Chattahoochee and Alabama river regions in Georgia and Alabama.

In 1906 the exposures of these beds on Chattahoochee River below Columbus, Ga., were examined by the writer, and during subsequent years numerous localities in Alabama and Georgia were visited. Various considerations, based upon physical evidence, led to the conclusions that the terrane was older than the Tuscaloosa formation; that it probably corresponded to the "Hamburg beds" of South Carolina, and to the "Cape Fear" formation of North Carolina; and that it was probably of Lower Cretaceous age. Mr. E. W. Berry, who, in company with the writer, later visited a number of the localities, concurred in these views.

The first and strongest argument in favor of this interpretation was the existence of a distinct unconformity separating the beds in question from the overlying Eutaw formation. This was noted unmistakably at the following places: McBride Ford on Upatoi Creek, Chattahoochee County; at the Lumpkin road bridge over Upatoi Creek a few miles above its mouth; on Chattahoochee River just below the mouth of Upatoi Creek; and at Broken Arrow Bend, nine miles below Columbus, Ga.; on the Seale road, four miles southwest of Columbus in Russell County, Ala., and on Alabama River, five miles above Montgomery, Ala. In addition to these the unconformity was questionably noted at several places intermediate between those mentioned. No such unconformity is known to exist between the true Tuscaloosa formation and the overlying Eutaw formation in central or western Alabama or in Mississippi.

The beds differ from the true Tuscaloosa deposits in the presence

[1] Langdon, D. W., Variations in Cretaceous and Tertiary Strata of Alabama: Bull. Geol. Soc. America, vol. 2, 1890, pp. 587-606.

[2] Veatch, Otto, Second report on the clays of Georgia: Geol. Survey of Georgia, Bull. No. 18, 1909, pp. 82-106.

[3] Clays of South Carolina: South Carolina Geol. Survey, ser. 4, Bull. No. 1, 1904, pp. 72-75.

[4] Some facts relating to the Mesozoic deposits of the Coastal Plain of North Carolina: Johns Hopkins University Circular, new series, July, 1907, No. 7 (whole number 199), pp. 93-99.

of a large percentage of white kaolin grains in the sands, rendering them arkosic; in the massive character of the clay lenses, thus contrasting with the laminated beds so common in the Tuscaloosa; and in the absence, except in rare instances, of fossil plant remains in the deposits. On the other hand, the beds strongly resemble the "Hamburg beds" of South Carolina, and the "Cape Fear" formation of North Carolina, and this fact, together with the fact of apparent continuity with the Carolina deposits, led to the belief that they were synchronous with them.

The "Cape Fear" formation is separated geographically from the Cretaceous deposits to the northward in Virginia by an overlap of Miocene beds. However, in all their physical characters they bear a close resemblance to the Patuxent formation which forms the basal division of the Potomac group in Virginia and Maryland. On account of this physical similarity, and because of their supposed buried connection with the Virginia Patuxent, the application of the name Patuxent has been extended to include these North Carolina arkosic beds.[1] Were it not for certain biological evidence to the contrary it would seem proper to extend the application of the name still farther to the southward to include the apparently continuous deposits in South Carolina, Georgia, and Alabama. Until recently no organic remains had been found in the beds in question south of the Virginia line. In the fall of 1910, the writer discovered a few poorly preserved plant remains in beds exposed in a bluff of Tallapoosa River at Old Fort Decatur, in Macon County, Ala. These have been submitted to Mr. E. W. Berry, who expresses the opinion that the beds containing them are of Lower Cretaceous age.

The previous conclusions regarding the age of the beds below the Eutaw formation seem thus to be confirmed by the paleontologic evidence. Unfortunately, the poorly preserved condition of the leaves renders it difficult to determine satisfactorily the relation of the formation to the Patuxent formation of Virginia and Maryland. However, in Mr. Berry's opinion, the presence of large numbers of leaves, apparently dicotyledons, most of which are too poorly preserved to permit of specific or even of generic determination, seems to justify doubt as to their being so old as the Patuxent formation, in which similar questionably identified dicotyledons are very sparingly represented. The following statement concerning the fossil remains of the Patuxent formation is quoted from a paper by Prof. Wm. B. Clark and Mr. Arthur Bibbins:[2]

[1] A report by the writer on the Cretaceous of North Carolina, now in press as a publication of the North Carolina Geological Survey.
[2] Geol. Soc. America, Bull., vol. 13, 1902, p. 192.

"The flora of the Patuxent formation includes equiseta, ferns, cycads, conifers, monocotyledons, and a very few archaic dicotyledons, the coniferous and cycadean element being particularly strong. The known fauna of the Patuxent formation is limited to a single unio (Ward) and a fish (Fontaine)."

Should future discoveries confirm this doubt the question would at once be raised as to the relation of these deposits to the "Cape Fear" formation of North Carolina, to which the use of the name Patuxent has been extended. Should the relation be found to be that of synchroneity the inappropriateness of the name Patuxent for either the Carolina or the Georgia-Alabama deposits would at once be apparent.

It may be stated here that although the "Cape Fear" beds appear to be continuous with the Lower Cretaceous beds of South Carolina, Georgia, and Alabama, it is quite possible that they are not actually continuous; for the irregular character of the bedding, the presence of numerous local unconformities within the beds, and the lack of extensive exposures, render the detection of an important unconformity difficult—and such an unconformity may exist.

An hypothesis suggested to the writer by Dr. T. Wayland Vaughan, which is also worthy of consideration, is that the arkosic beds extending from Maryland southward to Alabama were laid down along a coast margin which was gradually and continually depressed from the north to the south. In this case the deposits might actually be continuous and yet contain fossil plants at the southern end younger than those at the northern.

UPPER CRETACEOUS

EUTAW FORMATION

NAME

The name Eutaw group was proposed by Dr. Eugene W. Hilgard[1] in 1860, for deposits in Mississippi which he described as: "Bluish black, or reddish, laminated clays, often lignitic, alternating with, and usually overlaid by, non-effervescent sand, mostly (though not always) poor in mica, and of a gray or yellow tint." These constituted the basal portion of the Cretaceous deposits of the State, their lower limit being the surface of the Paleozoic rocks upon which they rested and their upper limit the base of the overlying Tombigbee sand group.

Explaining the use of the term Eutaw he says:[2] "I adopt this name in view of these beds having been first examined and recognized as being of Cretaceous age by Tuomey, near Eutaw, Alabama, where they are characteristically developed."

[1]Report on the geology and agriculture of the State of Mississippi, 1860, pp. 61-68.
[2]Op. cit., p. 61.

Tuomey's account of the beds near Eutaw to which Hilgard referred is recorded in the "First Biennial Report of the Geological Survey of Alabama," 1850, pp. 118-120.

Smith and Johnson,[1] in 1887, in their classification of the Alabama Cretaceous, adopted the name Eutaw, with, however, a modified meaning. According to their definition the base of the "rotten limestone" (Selma chalk) was made the upper limit of the formation, thus including the Alabama equivalents of Hilgard's Tombigbee sand, while below the Eutaw they differentiated a formation consisting of at least 1,000 feet of "purple and mottled clays interstratified with white, yellowish white, pink, and light purple, micaceous sands, and near the base of the formation dark, gray, nearly black, thinly laminated clay with sand partings," the Mississippi representatives of which Hilgard had included in his Eutaw group. For the latter they introduced the term Tuscaloosa formation.

The classification of Smith and Johnson expresses the difference between a series of irregularly bedded sands and clays of probable estuarine and non-marine origin, or perhaps in part of shallow marine origin, the Tuscaloosa formation, and a series of superjacent sands and clays clearly of marine origin, the Eutaw formation. The basis of this classification is regarded as the more logical and for this reason the nomenclature of the Alabama geologists is here used. The Tombigbee sand of Hilgard which thus becomes a part of the Eutaw formation, is roughly traceable eastward from Mississippi through Alabama, constituting the upper 150 or 200 feet of massive, more or less calcareous and phosphatic sands of the division, as distinguished from the more irregularly bedded sands and clays forming the lower 200 or 300 feet of the formation. This upper more massive portion was recognized by Smith and Johnson and was spoken of by them as the "upper member of the Eutaw formation." Although this so-called member can not be sharply differentiated from the less massive beds beneath it, it is eminently fitting that the original name applied to it in Mississippi should be perpetuated. It is therefore referred to in this report as the Tombigbee sand member of the Eutaw formation.

The Tuscaloosa formation, it is believed, is not represented in Georgia.

The Eutaw formation is represented in Georgia by the beds which Langdon[2] referred to the Eutaw group and by about 120 feet of overlying beds which formed the base of his "Ripley group," but which are, on paleontologic grounds, here considered synchronous with the Tombigbee sand member of the Eutaw formation.

[1]Bull. U. S. Geol. Survey, No. 43, 1887, pp. 71-138.
[2]Bull. Geol. Soc. America, vol. 2, 1891, pp. 587-606.

A. INDURATED LAYER OF FOSSILIFEROUS, MARINE SAND OF THE EUTAW FORMATION, IN BED OF OCHILLEE CREEK, AT OCHILLEE, CHATTAHOOCHEE COUNTY, GA.

B. EXPOSURE IN CUT OF COLUMBUS-LUMPKIN ROAD, THIRTEEN MILES SOUTH OF COLUMBUS, GA., IN CHATTAHOOCHEE COUNTY, SHOWING UNCONSOLIDATED SAND OF THE EUTAW FORMATION.

DEFINITION

Areal distribution.—The Eutaw formation is exposed in the bluffs of Chattahoochee River from a point a short distance below the mouth of Upatoi Creek, nine miles below Columbus, in Chattahoochee County, Ga., to a point two or three miles below the Seaboard Air Line Railway bridge at Omaha, in Russell County, Ala. Disregarding the irregularities of the stream's course, the formation has a north-south width of about 10 miles where it intercepts the river. To the northeastward away from the river the area becomes narrower, finally disappearing in Taylor County. It includes parts of Stewart, Chattahoochee, Marion, and Taylor counties (see map, opp. p. 58.) The formation outcrops in a belt having an average width of eight or ten miles extending from Chattahoochee River westward through Alabama and northward through Mississippi to the vicinity of the Tennessee State line.

Stratigraphic position.—The formation in Georgia rests unconformably upon beds of Lower Cretaceous age. The unconformity separating the two terranes is of considerable importance, for if the correlations indicated in this report are correct, the time interval represented by this unconformity in Georgia must be as long as the time required for the deposition of the Tuscaloosa formation and probably also a part of Lower Cretaceous time. To the west of Alabama River in Alabama, the underlying Lower Cretaceous strata disappear beneath the Tuscaloosa formation, the latter resting directly upon the basement rocks.

The Eutaw formation in Georgia is overlain by the Ripley formation. In limited areas bordering Chattahoochee River and Upatoi Creek the formation is overlain unconformably by thin Pleistocene terrace deposits.

Lithologic characters.—Considerable variation has been noted in the character of the materials of this formation, both vertically and horizontally. In the immediate Chattahoochee region they are in the main of marine origin, though a part of them was obviously laid down in very shallow marine waters, and some may even have originated in estuaries or sounds.

East of the river in the northeastern part of Chattahoochee County, in Marion County, and in Taylor County, the formation as a whole becomes much coarser and more irregularly bedded, and doubtless originated in shallow water, near shore, or even in sounds and estuaries. Thin beds of well-rounded pebbles have been observed in the formation at a few places in Georgia and also west of the river in Alabama. The upper marine portion of the formation which in this

report is referred to the Tombigbee sand member of the formation maintains its massive marine character to and beyond the Seaboard Air Line Railway northeast of Cusseta in Chattahoochee County. Still farther to the northeast in Marion County this division appears to give way to irregularly bedded sands and clays of shallow water origin.

In the region of Chattahoochee River the immediate base of the formation consists of a few feet of coarse, arkosic, micaceous sands bearing a rather close resemblance to the sands of the underlying Lower Cretaceous beds. Interbedded with these are subordinate lenses of drab to black, laminated, clay, bearing leaf remains in places. Scattered through these sands are considerable quantities of lignite in the form of comminuted particles, twigs, branches, and logs.

Immediately above the preceding occur 50 feet or more of medium to fine, gray to dark gray, more or less micaceous and calcareous sands and clays, indurated in some layers to a nodular, impure limestone. These materials are fossiliferous, and in places contain large numbers of shells and shell prints. The materials and the character of the entombed organisms prove this portion of the formation to be of marine origin.

The bluffs along Euchee Rapids, Chattahoochee River, reveal 40 feet or more of greenish gray, compact, marine clay, which lies closely above the preceding. This is followed by dark, laminated clays with thin, interbedded sand layers, examples of which may be seen in a bluff a short distance above the mouth of Euchee Creek. Coarse and fine sands locally indurated to ferruginous sandstone, all of shallow-water origin, are poorly exposed at Moores, Betons, and Codys rocks, between Euchee Creek and Chimney Bluff. These shallow-water beds are terminated upward by dark, lignitic clays and light to white, unconsolidated sands, which are well exposed at the base of Chimney Bluff. The clays at the latter place contain poorly preserved leaf remains. These beds are overlain conformably by the *Tombigbee sand member*, a description of which follows:

The irregularly bedded sands and clays just described are succeeded by massive marine beds having an estimated thickness of 120 feet, which were included by Langdon in the basal portion of his Ripley group, and formed a part of the "Blufftown marl" of Veatch. They are here referred, on paleontologic grounds, to the Tombigbee sand member of the Eutaw formation. The materials consist of gray or greenish gray, calcareous, more or less argillaceous sands with some interbedded layers of gray, calcareous, sandy clay. At vertical intervals of several feet the sands are indurated to impure, sandy limestones and calcareous sandstones, which by their greater resistance to

erosion form nodular projecting ledges along the faces of the bluffs. (See Pl. VIII.) The materials are more or less glauconitic and calcareous, and iron pyrites is fairly common. Fossil shells occur throughout the beds and certain layers contain them in sufficient abundance to form shell marls. The beds appear along the river in various exposures from Chimney Bluff to a point two miles below Omaha.

Strike, dip, and thickness.—On the Georgia side of Chattahoochee River, the beds of this formation strike approximately northeast and southwest. On the Alabama side the strike is nearly due east and west.

It has not been possible to obtain reliable dip measurements of that portion of the formation lying beneath the Tombigbee member of the formation, principally because of the irregularity of the bedding and because the exposures are not sufficiently extensive to show this feature. However, as is true of nearly all Atlantic and Gulf Coastal Plain formations, the amount of dip is relatively small. It is probable that the inclination of the beds is less than the general inclination of the unconformable surface of the underlying Lower Cretaceous deposits upon which the Eutaw formation rests. This unconformable surface, based upon calculations from well data, has an estimated dip of about 48 or 50 feet to the mile. The Tombigbee member of the formation is regularly bedded and exposures are continuous for considerable stretches along the river bluffs. In places indurated layers may be traced for distances of a mile or more. In general these dip down stream, but there are minor undulations and for short distances the dip may even be reversed. On account of these undulations it is not possible to determine the dip with accuracy, but it is believed Langdon's estimate, 20 feet to the mile, approximates the correct amount for the beds of this member in the immediate Chattahoochee region.

That portion of the Chattahoochee section here referred to the Eutaw formation was estimated by Langdon to be 465 feet thick, 345 feet being the figure given for his Eutaw group, which included the beds subjacent to the Tombigbee sand, and 120 feet for the overlying Tombigbee sand. The latter figure is probably approximately correct, but the former amout—345 feet—is known to be underestimated. A well at a landing on Chattahoochee River, two and one-half or three miles below the mouth of Euchee Creek, in Russell County, Ala., penetrated 362 feet of Eutaw strata before entering the underlying Lower Cretaceous beds. (See section p. 121 of this report.) Calculations based on the thickness shown in this well, and the width of outcrop on the river, give a total thickness of 435 or 440 feet for Langdon's

"Eutaw group," where it passes beneath the overlying Tombigbee sand member. This would give a total thickness for the formation, including the Tombigbee sand, of 555 or 560 feet.

Little is known of the thickness of the formation to the northeastward in Georgia, but it is believed that it gradually becomes thinner and at the eastern limit of its surface occurrence finally pinches out against the underlying older Cretaceous beds.

Physiographic expression.—The general upland surface of the belt of country in which this formation outcrops is a greatly dissected plain lying 450 to 500 feet above sea level. The weathering and leaching of the sand beds of the formation have produced a surficial covering of loose, gray sand varying in thickness from a few inches to eight or ten feet, which mantles the tops and slopes, giving to much of the country a "sand hill" aspect. In this respect the region resembles that previously described in which the Lower Cretaceous strata come to the surface. The surface relief reaches a maximum of 300 feet. The broken hilly aspect which characterizes the region in general has been modified by Pleistocene terracing processes in small areas bordering Chattahoochee River.

Paleontologic characters.—Marine invertebrate fossils are numerous in the lower 100 feet of the formation. Near the immediate base these are preserved as shells, shell prints, and internal casts. In beds somewhat higher they appear only as casts and prints. In the next 300 feet or more invertebrate fossils are rare, but a few soft prints of shells have been observed.

In the massive, marine sands and clays forming the upper 120 feet of the formation (Tombigbee sand member) invertebrate fossils are plentiful both as shells and as prints and casts.

Vertebrate animals are represented, so far as known, by the remains of sharks only. The teeth of these fishes are present in places in the massive, marine beds near the base, and in the Tombigbee sand member at the top of the formation.

The remains of plants are fairly abundant in certain parts of the terrane. Leaves have been collected at two localities from the nonmarine beds at the immediate base of the division, and also from the irregularly bedded sands and clays forming the base of the section at Chimney Bluff immediately beneath the beds of the Tombigbee sand member. Lignite is present at various horizons, as a rule in the form of small, widely scattered pieces. It is fairly abundant, however, in the basal leaf-bearing beds, and is very abundant in the leaf-bearing beds at Chimney Bluff.

The Tombigbee member of the formation forms the lower part of the zone *Exogyra ponderosa,* of which the lower one-third or one-half of the Ripley formation forms the upper part.

DETAILED SECTIONS. (PART OF FORMATION BELOW THE TOMBIGBEE SAND MEMBER.)

Chattahoochee River.—Exposures of this part of the formation appear in the bluffs of Chattahoochee River at intervals, from a point a short distance below the mouth of Upatoi Creek, nine miles below Columbus, Ga., to Big Bend, 24½ miles below Columbus. The specified localities are indicated in a sketch map of the river, Fig. 6. The exposure below the mouth of Upatoi Creek has already been described and the unconformable relation of the Lower Cretaceous strata to the overlying Eutaw formation indicated. (See section and sketch on p. 83.) The Eutaw materials consist of dark gray, finely arenaceous and micaceous, calcareous clay, with occasional grains of glauconite. The clay contains scattered lime concretions and there are a few imperfect shell impressions and an occasional piece of lignite.

On the right bank at Broken Arrow Bend, 10½ miles below Columbus, there is an exposure, a section of which is given below. (See plate VIII, A.)

Section at Broken Arrow Bend, Chattahoochee River, right bank.

	Feet.
Pleistocene (terrace deposit).	
2. Concealed by vegetation, except along the base, where a band of pebbles appears	10
(Unconformity.)	
Upper Cretaceous.	
Eutaw formation.	
1. Dark gray, calcareous, micaceous, finely arenaceous clay, with layers of lime concretions in nodular form, one to two and one-half feet apart in upper eight feet. Fossiliferous	13

At this point the Lower Cretaceous strata do not appear above water level. Fossils were collected and the following determined:

Chattahoochee River, Broken Arrow Bend, Alabama side, 10½ miles below Columbus, Ga., in Russell County. T. W. Stanton and L. W. Stephenson, collectors.

	Locality Numbers.		
	T.W.S. 847	L. W.S. 5384	L.W.S. 6409
Mollusca:			
Perna sp. nov.	x	x	x
Ostrea cretacea Morton	x	x	x
Exogyra upatoiensis Stephenson	x	x	x
Pecten sp.		x	
Anomia sp. nov. (Same as sp. nov. from Snow Hill, N. C.)		x	x
Cardium sp.	x	x	
Cyprimeria sp.		x	x
Baroda sp. nov.	x	x	x
Corbula carolinensis Conrad	x	x	
Pelecypod casts, undetermined		x	
Turritella sp.		x	
Placenticeras sp. (cf. P. guadalupae Roemer)		x	x
Gastropods casts, undetermined		x	
Vertebrata:			
Lamna texana Roemer		x	x
Otodus appendiculatus Agassiz		x	

A short distance below the preceding on the opposite side of the river, a good exposure occurs for several hundred yards along the base of a bluff 140 or 150 feet high. The Lower Cretaceous beds appear here for the last time, as one descends the river, being overlain unconformably by the beds of the Eutaw formation. The details of the section are as follows:

Section at Broken Arrow Bend, Chattahoochee River, left bank, 10½ miles below Columbus, Ga.

Upper 110 or 120 feet of slope concealed by vegetation.

	Feet.
Upper Cretaceous.	
Eutaw formation.	
3. Slightly laminated, gray, calcareous, micaceous, sand with impure lime nodules in layers two to three feet apart. Contains same fauna as the preceding locality	15
2. Coarse, crossbedded sand, and laminated clay, in part reworked from underlying Lower Cretaceous beds containing pieces of petrified wood, large logs and smaller pieces of lignite; fossil leaves were found in a lens of black clay eight inches thick, several feet above water level. The sand is gray or stained with iron and the clay is gray to black. These materials grade up conformably into the overlying materials	2 to 13

(Unconformity.)

Lower Cretaceous.

1. Characteristic gray sands and clays . . . . 0 to 5

E. W. Berry[1] furnishes the following list of plant species collected from Layer No. 2 in the above section:

Malapoenna horrellensis Berry
Phragmites pratti Berry
Salix eutawensis Berry
Salix flexuosa Newb.
Sequoia reichenbachi (Gein.) Heer

Down the river from the preceding locality the layers of concretions in the Eutaw formation dip gently southward, and at one-half mile below Broken Arrow Bend reach water level. At this point the following fossils were collected:

Locality No. 5386.—One-half mile below Broken Arrow Bend, 10 miles below Columbus, Ga.

Mollusca:
- Perna sp. nov.
- Ostrea cretacea Mort? (cf. sp. nov. from House Bluff, Alabama River.)
- Exogyra upatoiensis Stephenson
- Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.)

Vertebrata:
- Otodus appendiculatus Agassiz?

Before reaching Euchee Rapids, the upper end of which is about 13 miles below Columbus, the layers of lime nodules have passed beneath water level and, as shown by dredgings, they form the bed of the river at the upper end of the rapids and are the cause of the shoal water at that point.

A number of interesting exposures occur along the course of Euchee Rapids, on the right bank. Burdock Landing is one-half to three-quarters of a mile below the upper end of the rapids. The section exposed near the landing is as follows:

Section near Burdock Landing, Euchee Rapids, Chattahoochee River, right bank.

	Feet.
Pleistocene (terrace deposit)	
2. Yellowish sandy clay with band of gravel at base .	10 to 12
(Unconformity.)	
Upper Cretaceous.	
Eutaw formation.	
1. Greenish, somewhat laminated clay with fine sand partings, about	12 to 30

A short distance below the landing the following fossils were collected near the base of the bluff in Eutaw materials:

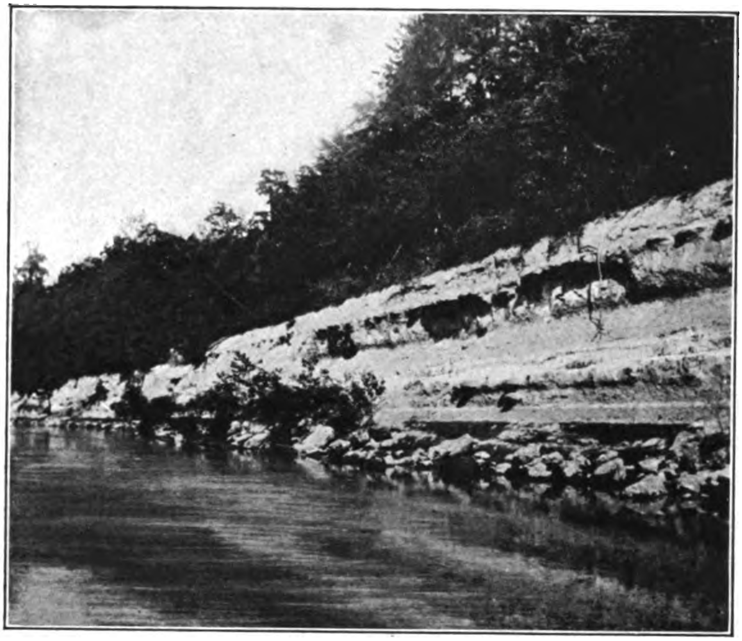
[1]Contributions to the Mesozoic flora of the Atlantic Coastal Plain, VI, Georgia: Bull. Torrey Botan. Club, No. 37, 1910, pp. 504.

Chattahoochee River, Burdock Landing, 13 or 14 miles below Columbus, Ga. T. W. Stanton and L. W. Stephenson, collectors. (All casts in clay.)

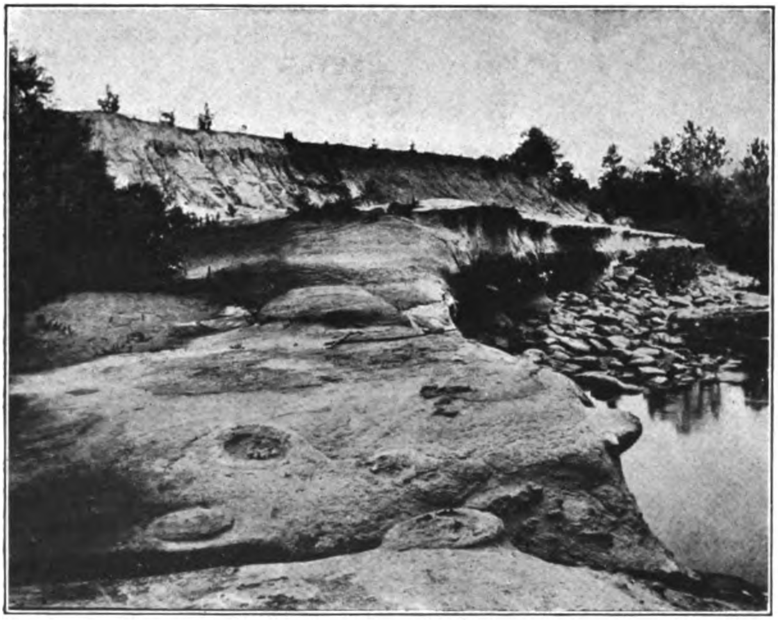
	Locality Numbers	
	T.W S. 848	L. W. S. 5886
Mollusca:		
Leda?		x
Breviarca sp.	x	
Perna sp. nov.	x	
Ostrea cretacea Morton? (cf sp. nov. from House Bluff, Alabama River)		x
Ostrea sp. nov. ? (aff. O. lugubris Conrad)	x	
Pecten sp. nov. (same as sp. nov. from Snow Hill, N. C.)		x
Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.)		x
Lucina sp.	x	
Cardium sp.	x	x
Cyprimeria depressa Conrad	x	x
Baroda sp. nov.	x	x
Cymbophora lintea (Conrad)		x
Corbula carolinensis Conrad	x	x
Undetermined gastropod casts	x	x

Slick Bluff begins about one-half mile below Burdock Landing and extends interruptedly for some distance along the right bank. (See plate IX, A.) The mass of the materials consist of greenish gray, compact clay, laminated in places. At some time in their history the clays have become fractured and the crevices thus formed filled with sand. The sand has become indurated and now appears as fine, white to light gray sandstone, forming dike-like masses in the clay. (See plate IX, B.) These have been described at some length and illustrated by Prof. S. W. McCallie.[1] Occasional casts of fossils are seen in the sandstone. The Eutaw clays appear to have been disturbed again in comparatively recent times, perhaps at some time during the Pleistocene or even the Recent epoch. This disturbance is evidenced by the fact that the bedding plains in the clay vary as much as 15 or 20 degrees from the horizontal, appearing at diverse angles at the different exposures along the bluff, and at several places poorly exposed fault plains were observed. In the woods back from the bluff for about one hundred yards, the surface presents sharp-crested ridges running parallel with the river bank, and in places the depressions between the ridges are undrained and hold stagnant pools of water. Some of the older and larger trees stand out of plumb. This topography is believed to have been produced by a series of land

[1]Am. Geol., vol. 32, October, 1903, pp. 199-202.



A. BLUFF BELOW BANKS LANDING, CHATTAHOOCHEE RIVER, TWENTY-SIX AND ONE-HALF MILES BELOW COLUMBUS, GA., LEFT BANK, SHOWING GRAY, CALCAREOUS SAND AND SANDY CLAY, WITH INDURATED LAYERS, BELONGING TO THE TOMBIGBEE SAND MEMBER OF THE EUTAW FORMATION.



B. BLUFF AT SNAKE SHOALS, CHATTAHOOCHEE RIVER, THIRTY MILES BELOW COLUMBUS, GA., RIGHT BANK, SHOWING GRAY, CALCAREOUS SANDS WITH ONE INDURATED LAYER, BELONGING TO THE TOMBIGBEE SAND MEMBER OF THE EUTAW FORMATION, OVERLAIN BY PLEISTOCENE DEPOSITS.

slides, the land slipping in sections, and at the same time becoming tilted. Several large masses of earth appear in the river as small islands, being apparently the remnants of masses which have slipped into the river at some time in the past.

In a chunk of clay, not in place, the following fossils in the form of casts were collected:

Chattahoochee River, Euchee Rapids, Slick Bluff, about 14½ miles below Columbus, Ga., right bank.

Mollusca:

Nucula sp.	Cyprimeria depressa Conrad
Breviarca sp.	Baroda sp. nov.
Ostrea sp. nov.? (aff. O. lugubris Conrad.)	Corbula carolinensis Conrad
	Undetermined pelecypod casts
Cardium sp.	Undetermined gastropod casts

About 200 yards above the mouth of Euchee Creek the following section is exposed:

Section about 200 yards above mouth of Euchee Creek, Chattahoochee River, right bank.

	Feet.
Pleistocene (terrace deposit)	
2. Sandy clay, grading down into sand, with a band of gravel along base	10
(Unconformity.)	
Upper Cretaceous.	
Eutaw formation.	
1. Dark gray laminated clay with seams and thin layers of white sand stained yellow in places with sulphur, and seams of finely comminuted lignitic matter	25

At Moores Rocks, 18 miles below Columbus, left bank, there are masses of coarse, ferruginous sandstone containing poorly preserved pelecypod casts in places.

At Betons Rocks, 19 miles below Columbus, masses of very coarse, in places pebbly, ferruginous sandstone appear in the bed and banks of the river.

A mass similar to the preceding appears at Codys Rock, 20¼ miles below Columbus.

At a landing two and one-half or three miles below the mouth of Euchee Creek, right bank, in Russell County, Alabama, there is a flowing artesian well. This well has been described by Prof. Eugene A. Smith[1] as follows:

"W. J. McLendon's well, near Chattahoochee River; depth, 465 feet. Record: Sand and clay, 20 feet; marl with shell, 65 feet; beds of sand and

[1]The Underground Water Resources of Alabama. Geol. Surv. of Alabama, Montgomery, 1907, p. 234.

marl, 15 to 25 feet thick, alternating, to 380 feet; hard rock, 2 feet; sand to 445 feet. Water at this point flowed 12 gallons per minute, but has decreased to four gallons. Well lowered 20 feet into sand to hard rock."

This well is located on the lowest Pleistocene terrace bordering the river. The mouth of the well is about 40 feet above zero water level. The first 20 feet of materials penetrated are Pleistocene terrace deposits; the materials from 20 to 382 feet probably belong to the Eutaw formation; and those from 382 to 465 feet probably belong to the Lower Cretaceous. This well, therefore, penetrates 362 feet of Eutaw beds at this point.

The next prominent exposure of Eutaw strata is at Chimney Bluff, 22 miles below Columbus. The section exhibited here at the time visited is as follows:

Section at Chimney Bluff, Chattahoochee River, left bank, about 100 yards up stream from the high, prominent part of the bluff.

	Feet.
Upper Cretaceous.	
Eutaw formation.	
(Tombigbee sand member).	
4. Greenish yellow, finely arenaceous, weathered, marine clay	6
3. Dark gray, massive, argillaceous, fine, marine sand, showing some sulphur stain on surface. In this was recognized casts of *Inoceramus sp.*, *Crassatellites sp.*, and *Cyprimeria depressa* Conrad	12
(Part of formation below the Tombigbee sand member.)	
2. Fine, light gray to almost white, loose, finely cross-bedded, micaceous sand, with occasional clay films	15
1. More or less irregularly bedded, dark, laminated, lignitc clay and loose, micaceous sand. In places there are lenses of extremely black micaceous sand, and at other places lenses of slate-colored, extremely micaceous sand. Lignite is present in great abundance in all forms, from comminuted particles up to large logs. Poorly preserved fossil leaves, representing several species are present in abundance in some of the clay lenses	20

Layers Nos. 3 and 4 of the preceding section are referred to the Tombigbee member of the Eutaw formation.

Down stream towards the high part of the bluff the white sand layer described in the preceding section becomes obscured by landslide material and vegetation, and in the high bluff proper it appears to be represented by lenses of greenish gray, sandy clay and subordinate lenses of dark to black clay. Above the clay in this high part of the bluff are 40 to 50 feet of yellowish, sandy, marine clay apparently

weathered from darker marine materials which belong to the Tombigbee member of the formation.

E. W. Berry[1] has recognized from layer No. 1 of the above section the plant species listed below:

Araucaria bladenensis Berry.
Araucaria bladenensis Berry
Ficus crassipes Heer
Ficus Krausiana (Authority ?)
Salix flexuosa Newb.
Salix Lesquereuxii Berry
Sequoia Reichenbachi (Gein.) Heer

On the left bank at the Racepasses, about 23½ miles below Columbus, the following section is exposed:

Section at the Racepasses, Chattahoochee River, left bank, about 24 miles below Columbus.

Upper Cretaceous.	
Eutaw formation.	Feet.
(Tombigbee sand member.)	
2. Dark greenish gray, compact, sandy clay, containing casts of pelecypods, *Pecten burlingtonensis* Gabb recognized	14
(Part of formation below the Tombigbee sand member.)	
1. Laminated, crossbedded, lignitic sands and clays similar to lower 20 feet of the section of Chimney Bluff	12

At Big Bend, 24½ miles below Columbus, Ga., right bank, Eutaw strata consisting of irregularly bedded, dark to black, laminated clays and white, crossbedded sands make up the lower 12 to 15 feet of the bluff. These are overlain conformably by several feet of gray, marine sands with fossils referable to the Tombigbee member of the formation. (See list of fossils, p. 108 of this report.) Pleistocene terrace materials make up the upper part of the bluff above the fossiliferous, gray sands.

Region between Chattahoochee and Flint rivers.—Good exposures of that part of the formation beneath the Tombigbee sand member occur to the east of Chattahoochee River in Muscogee and Chattahoochee counties. In the former county the formation is present in an area several miles in width, running east and west in the southern part of Muscogee County, where it forms the upper 100 to 140 feet of strata in the hills lying to the north of Upatoi Creek.

The best exposure of the formation observed in the county is on the Cusseta Road, where it passes up the scarp from the first or lowest

[1]Contributions to the Mesozoic flora of the Atlantic Coastal Plain—VI, Georgia: Bull. Torrey Botan. Club No. 37, 1910, pp. 504-505.

Pleistocene terrace plain, one and one-half miles southeast of Bull Creek, to the top of the upland one-half mile farther to the southeast. (See topographic map of Columbus Quadrangle.) The section exposed along this road for a distance of about one-half mile is as follows:

Section along Cusseta Road, one and one-half to two miles southeast of Bull Creek, Columbus Quadrangle, Ga.

	Feet.
Upper Cretaceous.	
Eutaw formation?	
11. Red, stratified, argillaceous sand	10
10. Interstratified red sand and light, harsh clay layers with a line of pebbles and cobbles along base	8
Eutaw formation.	
9. Fine, light, argillaceous sand (weathered)	6
8. Laminated, fine sand and clay with iron crusts, mostly brown in color, due to weathering . . .	7
7. Mottled, marine sand and clay (weathered) . . .	10
6. Greenish, drab, finely arenaceous, marine clay . .	10
5. Fine, white, marine sand more or less streaked with red and yellow due to weathering	10
4. Mottled, argillaceous, marine sand, (much weathered)	17
3. Greenish gray, argillaceous, marine sand	27
2. Coarse, crossbedded sand with kaolin grains and irregularly distributed clay balls	15
(Unconformity, somewhat obscured by weathering.)	
Lower Cretaceous.	
1. Medium coarse, crossbedded sand, arkosic in part	20

Another interesting exposure of the formation in which its relations to the underlying Lower Cretaceous division is exhibited occurs on the Steam Mill Road, seven miles a little south of east of Columbus. This road is the first road south of the Buena Vista road. (See Columbus Quadrangle.)

Section, Steam Mill Road, seven miles a little south of east of Columbus, on westward facing slope of Tiger Creek Valley.

	Feet.	In.
Upper Cretaceous.		
Eutaw formation.		
5. Dark red, weathered, finely arenaceous clay with numerous plate-like iron concretions	4	
4. Light greenish gray, fine, compact, micaceous, somewhat argillaceous sand containing fossil prints, with numerous, irregular, proportionately short and thick lenses, or segregations of compact, white, slightly micaceous sand, the latter partially surrounded on their under surfaces with layers or films of dark, drab clay. Shell prints occur rarely in the white sand lenses, ... about		10

3. Band of fine, dark, greenish gray, micaceous sand, pyritiferous in places, not sharply separated from layers above and below, filled with soft prints of shells . . . . about	2	6
2. Band of coarse and fine sand lenses, with poorly preserved shell prints . . . . about	2	6
(Unconformity, rendered somewhat obscure by weathering, but apparently marked by an irregular line of iron crusts.)		
Lower Cretaceous.		
1. Irregularly bedded, light gray, coarse arkosic sand, with subordinate lenses of light, massive clay more or less sandy . . . . about	80	

The white sand masses in layer No. 4 of the above section are not mechanically included chunks, as might at first be suspected from the conglomeratic appearance of the bed and from its close proximity to the base of the formation, neither are they of concretionary origin. Apparently the white sand has been segregated by a sorting process of some kind while deposition was in progress. (See plate B, opposite p. 96.)

The forms listed below were collected from the fossiliferous layers of the foregoing section, principally from layer No. 3.

Locality No. 6410.—Steam Mill Road, seven miles a little south of east of Columbus, Ga., westward-facing slope of Tiger Creek Valley. L. W. Stephenson, collector.

Mollusca:
- Nucula sp.
- Perna sp. nov. (probably same as at Broken Arrow Bend.)
- Cardium sp.
- Cymbophora lintea (Conrad).
- Corbula carolinensis Conrad.
- Anchura sp.

On this same road about one and one-half miles farther to east, weathered marine Eutaw materials were seen on the top of the divide between Steam Mill and Wolf Creek.

In Chattahoochee County strata belonging to this part of the Eutaw formation have produced the surface materials in a belt four to eight miles wide south of Upatoi Creek, embracing about one-half of the total area of the county, excepting, however, limited areas along Chattahoochee River and Upatoi Creek where the Eutaw beds are covered by relatively thin Pleistocene terrace deposits. The basal beds have been examined at three localities on Upatoi Creek.

Just above the bridge of the Columbus-Lumpkin road, seven and one-half miles south of Columbus, 10 feet of characteristic light gray, compact sands and clays of the Lower Cretaceous occur beneath several feet of dark, calcareous, marine sands and clays of the Eutaw formation. The extent of the exposure is small, but the contact between the two formations, where observed, is sharp and somewhat irregular, and is believed to represent an important time interval

The details of another important section on Upatoi Creek below the Columbus-Cusseta road bridge is given in the following section:

Section on Upatoi Creek one-quarter mile below the bridge of the Columbus-Cusseta road, seven miles southeast of Columbus, Ga.

	Feet.	In.
Upper Cretaceous.		
Eutaw formation.		
9. Brown, unconsolidated sand (weathered marine sand)	5	
8. Greenish, partially weathered irregularly foliated fine sand and clay	5	
7. Fine-grained white sandstone	1	
6. Greenish, irregularly foliated, fine sand and clay	2	
5. Dark greenish gray, argillaceous sand	5	
4. Fine-grained, white sandstone	1	6
3. Very fine-grained, dark greenish gray, argillaceous clay with fine, irregular, dark clay foliations. Contains discontinuous, nodular limestone layers and irregularly distributed lime concretions. Scattered fragments of lignite present in the materials. Fossiliferous	25	
(Unconformity, contact not well exposed.)		
Lower Cretaceous.		
2. Light gray, coarse, crossbedded, more or less arkosic sand, partially streaked with yellow, with subordinate, sandy clay layers	22	
1. Concealed to water level	30	

The forms listed below were collected from the fossiliferous layer in the preceding section:

Bluff of Upatoi Creek, seven miles southeast of Columbus, Ga., below the Cusseta Road bridge. Otto Veatch and L. W. Stephenson, collectors.

	Locality Numbers	
	O.V. 5878	L.W.S. 5877
Leda sp. nov. ?		x
Cucullaea ?		x
Perna sp. nov.	x	x
Ostrea cretacea Morton	x	x
Exogyra upatoiensis sp. nov.	x	x
Pholadomya sp. nov.		x
Cardium sp.		x
Baroda sp. nov.		x
Corbula carolinensis Conrad		x
Undetermined pelecypods		x
Turritella sp.	x	
Anchura sp.	x	
Undetermined gastropods	x	
Vertebrata:		
Lamna texana Roemer	x	
Corax falcatus Agassiz	x	
Otodus ?	x	

The third locality mentioned is on Upatoi Creek near McBride Ford, 11 miles (air-line distance) south of east of Columbus, Ga. The exposure is on the south bank of the creek a short distance above the ford. The details of the sections are described on page 86 of this report. The relations of the three formations appearing in the bluff are illustrated in the following sketch:

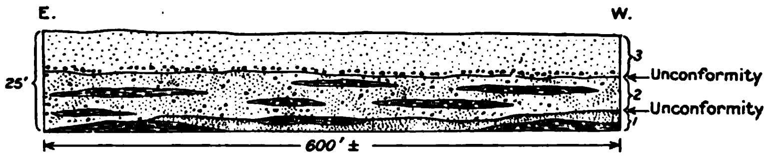


Fig. 9. Sketch showing the relations of Lower Cretaceous beds and the Eutaw formation to each other and to overlying Pleistocene terrace deposits.

Explanation of sketch.

3. Pleistocene terrace deposit.—Principally loose sand with a gravel band along base.
2. Eutaw formation.—Irregularly bedded, coarse, arkosic, crossbedded sand with subordinate, chocolate to black clay lenses. The sand is in places full of small, angular, quartz pebbles and some feldspar fragments, the basal portions being especially coarse. The materials contain considerable lignite, some of which is in the form of fairly large logs. The clay lenses contain leaf impressions, for the most part imperfect. However, from one dark lens, six to ten inches thick, near the lower end of the bluff, a number of well preserved leaves were collected.
1. Lower Cretaceous.—Characteristic, light gray, compact, arkosic sand and drab clay, breaking with hackley fracture.

The Pleistocene terrace bordering the creek on the south side at McBride Ford is only a few rods wide. The hills immediately to the south rise 240 feet above the creek bed. The strata making up the body of these hills belongs to the Eutaw formation, but no good exposures were seen in this immediate vicinity.

The contact between the Lower Cretaceous beds and the Eutaw formation at the McBride Ford locality is undulating and is sufficiently sharp to be easily traceable along the bluff. Although the materials above and below the contact do not differ markedly, the former having been derived largely from the latter, yet there is a recognizable physical difference. The beds below are more compact, are free from lignite, and the clays are non-laminated, breaking with a hackley fracture. The materials above are less compact, show greater signs of current activity during deposition, contain considerable lignite, and the clays are laminated.

E. W. Berry[1] has identified from this locality the plant species listed below:

Andromeda cretacea Lesq. ?
Andromeda wardiana Lesq.
Androvettia elegans Berry
Aralia eutawensis Berry
Brachyphyllum macrocarpum Newb.
Cinnamomum heerii Lesq.
Cinnamomum Newberryi Berry
Eucalyptus angusta Velen.
Ficus ovatifolia Berry
Manihotoides georgiana Berry
Juglans arctica Heer ?
Magnolia boulayana Heer
Magnolia capellinii Heer
Menispermites variabilis Berry
Paliurus upatoiensis Berry
Salix flexuosa Newb.
Sequoia Reichenbachi (Gein.) Heer
Tumion carolinianum Berry ?
Zizyphus laurifolius Berry

Several other exposures of the formation have been studied in the county. At Ochillee there is exposed in the bed of Ochillee Creek about 16 feet of Eutaw materials, consisting of layers of impure limestone interstratified with layers of marine sand. (See plate X, A.) Fossils partially in the form of casts are abundant. The horizon is probably slightly higher than the fossiliferous layer, No. 3, described in the section on Upatoi Creek below Columbus-Cusseta road bridge. Veatch has published the following more complete section of the strata exposed at and near Ochillee. (Clay report, p. 91.)

Ochillee Creek, Section at Ochillee.

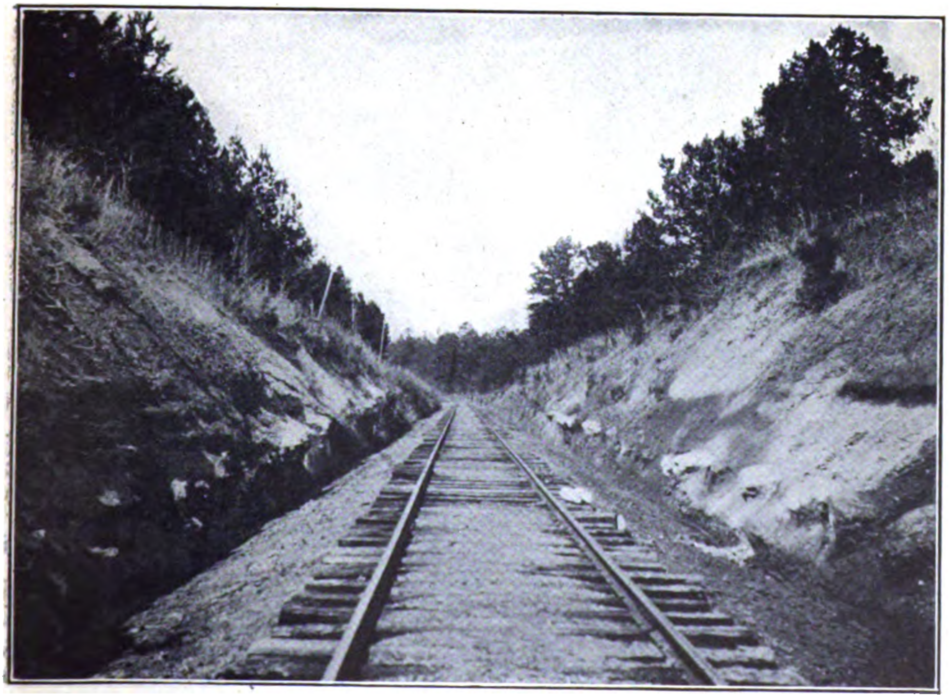
		Feet.
5.	Brown or yellow, unconsolidated sand (at top) . .	
4.	Blue or black, laminated, sandy clay, "marl" . .	40
3.	Sandstone	4
2.	Dark gray calcareous sandstone. In places the bed is composed almost entirely of shells	4
1.	Black and gray micaceous, calcareous sand; contains poorly preserved shells and lignite . . .	8

Layer No. 4 of Veatch's section probably corresponds to the thick clay bed exposed at Slick Bluff, and other bluffs along Euchee Rapids, Chattahoochee River.

The following fossils have been recognized at the Ochillee locality:

[1]Contributions to the Mesozoic flora of the Atlantic Coastal Plain—VI Georgia: Bull. Torrey Botan. Club No. 37, 1910, p. 504.

A. BLUFF AT BLUFFTOWN, GA., THIRTY-ONE AND ONE-QUARTER MILES BELOW COLUMBUS, GA., SHOWING GRAY, CALCAREOUS SANDS AND CLAYS, WITH INDURATED CALCAREOUS LAYERS BELONGING TO THE TOMBIGBEE SAND MEMBER OF THE EUTAW FORMATION.



B. EXPOSURE IN CUT OF SEABOARD AIR LINE RAILWAY, TWO AND ONE-HALF MILES NORTHWEST OF CUSSETA, CHATTAHOOCHEE COUNTY, GA., SHOWING GRAY, MARINE SANDS WITH A LAYER OF CALCAREOUS CONCRETIONS NEAR THE BASE, BELONGING TO THE TOMBIGBEE SAND MEMBER OF THE EUTAW FORMATION.

Bed of Ochillee Creek at Ochillee, Chattahoochee County, Ga. Otto Veatch and L. W. Stephenson, collectors.

	Locality Numbers	
	O.V. 5374	L.W.S. 5378
Vermes:		
Serpula sp.	x	x?
Mollusca:		
Nucula percrassa Conrad		x
Cucullaea sp.	x	x?
Trigonoarca sp.		x
Breviarca ?	x	x
Glycymeris sp.		x
Perna sp. nov.	x	x?
Ostrea cretacea Morton	x	x?
Pecten sp.		x
Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.)	x	x?
Etea carolinensis Conrad	x	x?
Crassatellites ?		x
Cardium sp.	x	x?
Cyprimeria depressa Conrad ?		x
Baroda ?		x
Leptosolen biplicata Conrad		x
Cymbophora lintea (Conrad)	x	x?
Corbula carolinensis Conrad	x	x
Undetermined pelecypods	x	x
Turritella sp.	x	x?
Anchura sp.	x	x?

About three-quarters of a mile southeast of Ochillee on the Seaboard Air Line Railway, a shallow cut reveals at its base two feet of dark to black, finely micaceous marine clay, containing fossil casts, among which the following were recognized:

Nucula percrassa Conrad
Leda sp.
Inoceramus sp.
Cardium sp.
Legumen planulatum (Conrad)
Corbula carolinensis Conrad

This clay probably corresponds in stratigraphic position to the base of the clay bed at the Euchee Rapids exposures above mentioned.

At Sulphur Springs on the Seaboard Air Line Railway, 13½ miles southeast of Columbus, there are poor exposures of coarse, yellow sandstone. A cut on the same railroad one-half mile farther to the southeast, reveals 15 feet of medium to coarse-grained, crossbedded sand with occasional thin, light drab clay layers irregularly interstratified. These two last occurrences probably correspond stratigraphically to the coarse, ferruginous rocks on Chattahoochee River from 20 to 22 miles below Columbus.

At 14½ miles southeast of Columbus a cut of the Seaboard Air Line Railway shows several feet of irregularly bedded, thinly laminated dark and light micaceous clay with lenses of fine to coarse sand. Stratigraphically, these materials probably correspond approximately to the irregularly bedded sands and clays making up the lower 20 feet of the section at Chimney Bluff on Chattahoochee River.

In a well on the property of J. R. Christian, four miles west of Ochillee, water was secured in soft, white sand at a depth of 60 feet below the surface. This sand is probably referable to the Eutaw formation. The owner is authority for the lithology.

The log of a well on the property of A. K. Cook, two miles east of Shack, Ga., is given below; the owner is authority for the lithology.

Log of well on property of A. K. Cook, two miles east of Shack, Ga.

		Feet.
Upper Cretaceous		
Eutaw formation.		
6. Sand		0 to 3
5. Clay		3 " 21
4. Sand rocks and coarse sand		21 " 41
3. Fine white sand, almost as fine as flour, and as white as snow		41 " 47
2. Coarse gravel	about.	47 " 100
1. Coarse red sand, almost as red as blood	about.	100 " 104

On the Columbus-Lumpkin road, 11 miles south of Columbus, the southward-facing slope of Gilbert Creek Valley presents the following section:

Section Columbus-Lumpkin road, 11 miles south of Columbus, Ga., southward-facing slope of Gilbert Creek Valley.

	Feet.
Pleistocene (second terrace above the river).	
6. Loose, gray surface sands	3
5. Mottled pink and yellow, micaceous, argillaceous sand	10
4. Gravel bed with coarse, arkosic sand matrix	13
(Unconformity.)	
Upper Cretaceous.	
Eutaw formation.	
3. Laminated, drab clay and fine, yellow micaceous sand	6
2. Mottled gray, red, and yellow, coarse to fine sand	18
1. Drab, laminated clay with seams of comminuted plant remains	2

On the same road 13 miles south of Columbus the northward-facing slope of Oswichee Creek Valley furnishes the following section:

Section Columbus-Lumpkin road, northward-facing slope of Oswichee Creek Valley, 13 miles south of Columbus, Ga.

Upper Cretaceous.	
Eutaw formation.	Feet.
3. Compact, red, ferruginous, faintly stratified sand	15
2. Laminated, drab clay and yellow and red, fine to coarse, micaceous sand with some conspicuous lenses of more compact, laminated clay	12
1. Fine to medium coarse, loose, light gray to yellowish sand with scattered clay laminae throughout	50

Detailed information concerning the extension of the formation to the northeastward in Marion and Taylor counties is lacking. However, the beds are known to become coarser and more irregularly bedded, and probably represent near-shore and estuarine phases of the formation. The Tombigbee sand member, described in later pages, which makes up the upper part of the formation, probably also merges to the northeastward into similar shallow-water beds. These resemble so closely the sands and clays of the overlying Cusseta sand member of the Ripley formation that it is not possible to differentiate them without a considerable amount of very detailed work.

A "black marly clay," which probably represents the northeastward extension of the formation, was encountered at depths of 60 to 73 feet in a well one and one-half miles north of Mauk, on the property of J. L. Whitley, who is authority for the statement.

DETAILED SECTIONS. (TOMBIGBEE SAND MEMBER.)

Chattahoochee River.—The Tombigbee sand member appears in the bluffs of Chattahoochee River from Chimney Bluff, 22 miles below Columbus, to a point about two miles below Omaha bridge, 39 miles below Columbus. (For the location of the various exposures described, see sketch map of the river, figure 6, p. 79.)

The upper 50 feet of strata exposed at Chimney Bluff, Chattahoochee River, is regarded as the probable base of this division. (See detailed section, p. 122 of this report.) The material consist of yellowish, sandy, marine clay (dark greenish gray where unweathered in nearby ravines) containing a few imperfect prints of fossils. There is no structural break between this and the underlying beds, the relation being that of conformity. The base of the Tombigbee sand, as interpreted, at the stage of water when visited (about normal) was 35 feet above water level.

The fossils listed below have been recognized from the Tombigbee sand at Chimney Bluff:

Chattahoochee River, Chimney Bluff, Chattahoochee County, Ga., 22 miles below Columbus, Ga. T. W. Stanton and L. W. Stephenson, collectors.

	Locality No.	
	T.W.S. 846	L. W. S. 6407
Mollusca:		
Cucullaea sp.	x	x
Inoceramus sp.	x	x
Crassatellites sp.	x	x
Cyprimeria depressa Conrad	x	x
Aphrodina sp.	x	
Corbula carolinensis Conrad	x	
Undetermined gastropod	x	

At the Racepasses, about 23½ miles below Columbus, left bank, the base of the Tombigbee sand is 12 feet above water level. (See detailed section, p. 123 of this report.) The materials here consist of 14 feet of dark, greenish gray, compact, sandy clay, containing casts of pelecypods, among which *Pecten burlingtonensis* Gabb was recognized. At this place also the relations between the two divisions appeared to be that of conformity.

At Big Bend, 24½ miles below Columbus, right bank, a few feet of gray, marine sand overlies 12 to 15 feet of laminated clays and sands. The former is referred to the Tombigbee sand. The Tombigbee materials are overlain by Pleistocene terrace deposits. At one point a mass of slightly indurated Tombigbee sand has slipped into the river, being partially exposed at low water, from which were collected the following fossils:

Locality No. 5888.—Big Bend 24½ miles below Columbus, Ga., right bank. L. W. Stephenson, collector.

Mollusca:

Cucullaea sp.
Inoceramus sp.
Exogyra ponderosa Roemer
Pecten sp.
Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.)
Etea carolinensis Conrad
Lucina glebula Conrad ?
Cardium sp.
Cyprimeria depressa Conrad
Aphrodina sp.

Below Big Bend the Eutaw formation is represented by beds of the Tombigbee member only.

A bluff at Planters Landing, 25 miles below Columbus, presents at its base 25 or 30 feet of dark green, finely arenaceous, marine clay, containing fossil remains. A conspicuous layer made up of

specimens of *Exogyra ponderosa* Roemer occurs 12 or 15 feet above zero water level. Of the fossils collected here the following were identified:

Loc. No. 5389.—Planters Landing, 25 miles below Columbus, Ga., left bank. L. W. Stephenson, collector.

Vermes:
- Hamulus major Gabb
- Molusca:
- Cucullaea sp.
- Nemodon sp.
- Inoceramus sp.
- Ostrea sp.
- Exogyra ponderosa Roemer
- Lima sp.
- Anomia argentaria Morton
- Etea carolinensis Conrad
- Crassatellites sp.
- Lucina glebula Conrad ?
- Cardium (Trachycardium) alabamense Gabb ?
- Cyprimeria depressa Conrad
- Cyclothyris ?
- Aphrodina sp.
- Cymbophora lintea (Conrad) ?
- Corbula carolinensis Conrad ?
- Turritella quadrilira Johnson ?

At Banks Landing, 26½ miles below Columbus, left bank, the bluff reveals 25 or 30 feet of marine materials referable to the Tombigbee member, consisting of light gray, calcareous clay and glauconitic sand, with indurated, concretionary, calcareous layers several feet apart. (See plate XV, A.)

Fossils are fairly numerous, and the following were collected and identified:

Chattahoochee River, Banks Landing, Stewart County, Ga., 26½ miles below Columbus, Ga. Collector, L. W. Stephenson.

	Locality Number	
	5390	6406
Coelenterata:		
Undetermined coral	x	
Vermes:		
Serpula sp. (nearly straight tube)	x	
Hamulus major Gabb	x	x
Hamulus onyx Morton	x	
Mollusca:		
Nucula sp. (cf. nov. from Snow Hill, N. C.)		x
Nucula sp.	x	
Leda pinnaforma Gabb ?	x	
Leda longifrons Conrad	x	x
Leda sp. (cf. L. gabbana (Whitfield)		x
Breviarca saffordi Gabb ?	x	
Breviarca (cf. B. umbonata Conrad)		x
Nemodon sp. nov.	x	x
Gervilliosis ensiformis (Conrad)	x	x
Perna ?		x
Inoceramus sp.	x	x
Ostrea cretacea Morton	x	x
Ostrea plumosa Morton		x

	Locality Number	
	5890	6406
Gryphaea vesicularis Lamarck ? (young)	x	
Gryphaea aucella Roemer		x
Exogyra ponderosa Roemer		x
Exogyra ponderosa var. erraticostata Stephenson		x
Trigonia sp.	x	x
Pecten quinquecostatus (Sowerby)	x	x
Pecten simplicius Conrad	x	
Pecten burlingtonensis Gabb	x	
Pecten sp.	x	
Lima reticulata Morton		x
Anomia argentaria Morton		x
Anomia sp. nov. (same as sp. nov. Snow Hill, N. C.)	x	x
Liopistha sp.	x	x
Veniella conradi (Morton)		x
Etea carolinensis Conrad		x
Vetericardia crenalirata (Conrad)	x	x
Crassatellites sp. (cf. C. carolinensis Conrad)	x	x
Tenea sp.	x	
Cardium (Trachycardium alabamense Gabb)		x
Isocardia sp.		x
Cyprimeria depressa Conrad		x
Aphrodina ?		x
Legumen planulatum (Conrad)	x	x
Linearia metastriata Conrad		x
Cymbophora lintea (Conrad)	x	
Corbula crassiplica Gabb	x	
Corbula sp.	x	x
Dentalium sp. nov. (cf. new species from Owl Creek, Miss.)	x	
Astralium ?	x	x
Lunatia obliquata M. & H.		x
Lunatia sp.	x	
Turritella quadrilira Johnson	x	x
Pterocerella tippana Conrad ?		x
Anchura sp.		x
Mortoniceras sp. (aff. M. texanum Roemer)		x
Undetermined gastropods	x	

A bluff near the upper end of Snake Shoals, left bank, 29 or 29½ miles below Columbus, presents materials very similar in appearance to those at Banks Landing.

At the sharp bend to the left just above the mouth of Snake Creek, right bank, 30 miles below Columbus, a prominent bluff reveals materials of the same character as the preceding. Good specimens of *Exogyra ponderosa* Roemer occur here. See plate XI, B, opposite page 120.)

At Blufftown, 31¼ miles below Columbus, the river strikes against a hill having a height of about 195 feet above zero water level. Only the basal 40 feet of the bluff is well exposed, but from

poor exposures the following section has been made out roughly: (See plate XII, A.)

Section at Blufftown, Chattahoochee River, 31 1/4 miles below Columbus, Ga., left bank.

Upper Cretaceous	
Ripley formation	
(Cusseta sand member).	Feet.
4. Red and yellow, unconsolidated sand, containing small pebbles and thin limonite crusts	100
(Typical marine beds)	
3. Gray, calcareous, marine sand with some fossils	50
Eutaw formation (Tombigbee sand member).	
2. Gray, calcareous, glauconitic sand with indurated, nodular, concretionary layers several feet apart, about	35
1. Gray, calcareous, finely arenaceous, fossiliferous clay, about	10

Layers Nos. 1, 2, and 3 of the preceding section constitute parts of Veatch's "Blufftown marl."

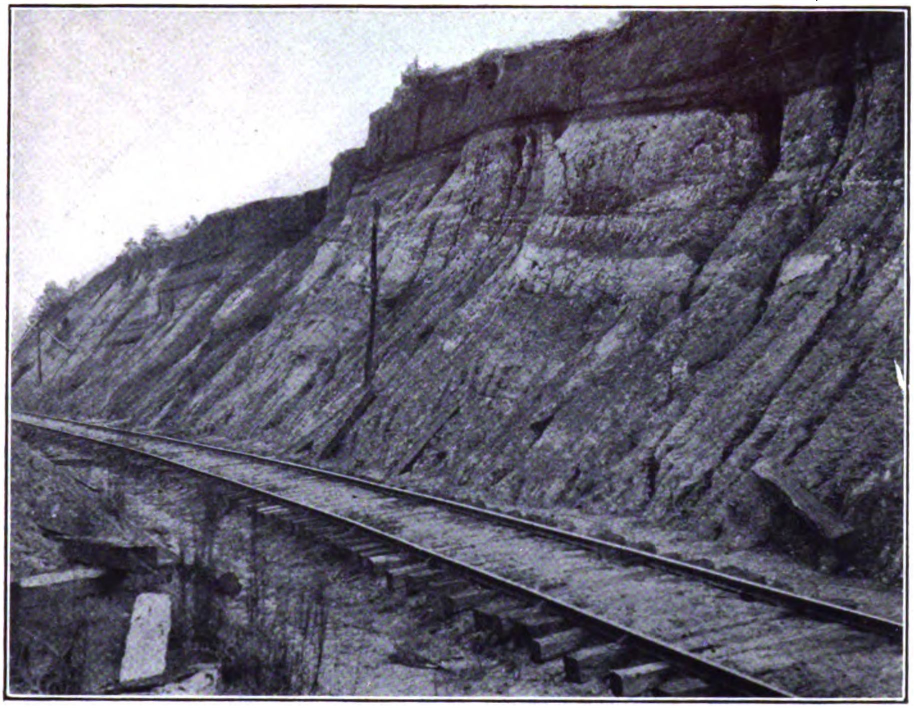
Near the top of layer No. 3 were obtained *Ostrea plumosa* Morton, a young individual of *Exogyra,* with costae, and *Anomia* sp. nov. (cf. new species from Snow Hill, N. C.). The fossils listed below were obtained from layers Nos. 1 and 2; but the principal fossil bed is layer No. 1.

The Tombigbee sand and the overlying Ripley formation are conformable, and the materials above and below the dividing line, as indicated in the above section, are very similar physically. The division is made upon paleontologic grounds, and principally upon the evidence of a fairly typical though small specimen of *Exogyra,* with costae, in layer No. 3, which in western Alabama and eastern central Mississippi is not known to occur so low as the Tombigbee sand. One or two species in layers Nos. 1 and 2 are relied upon as evidence that this portion of the section should be referred to the Tombigbee sand. A future more perfect understanding of the vertical range of the included forms may establish the necessity of raising or lowering this line of division.

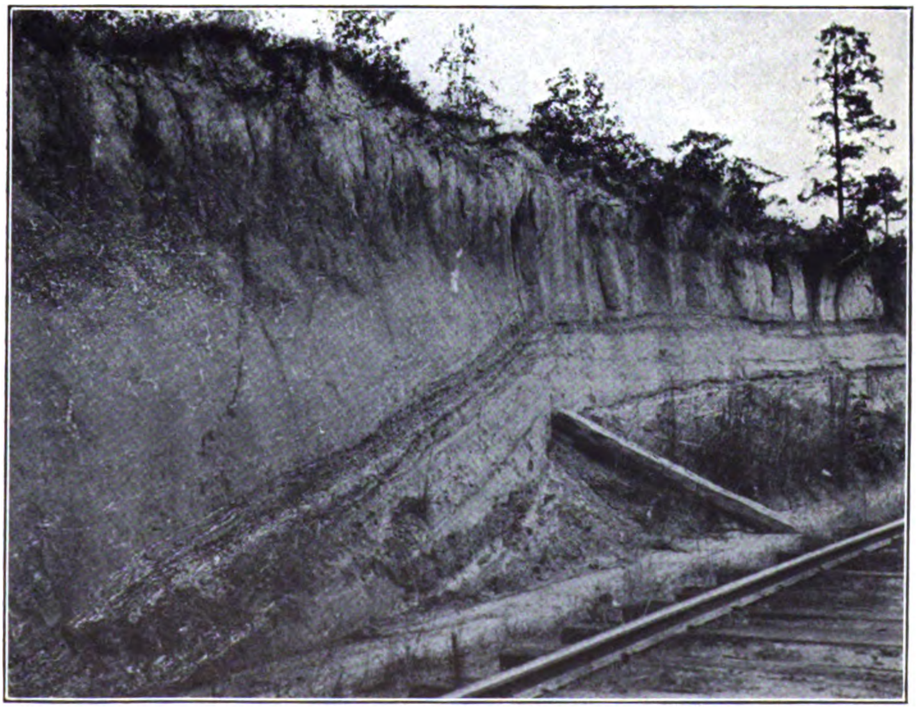
Chattahoochee River, bluff at Blufftown, Stewart County, Ga., 31¼ miles below Columbus, Ga. Collectors, T. W. Stanton and L. W. Stephenson.

Less than 45 feet above zero water level:

	Locality Nnmbers		
	T.W.S. 844	L.W.S. 5892	L.W.S. 6405
Vermes:			
Serpula sp. (nearly straight tube)	x	x	x
Hamulus major Gabb	x	x	x
Mollusca:			
Nucula percrassa Conrad	x	x	x
Nucula eufalensis Gabb		x	x
Leda sp.		x	
Cucullaea carolinensis Gabb	x	x	x
Trigonoarca sp. (young individual ?)		x	
Perrisonota protexta Conrad		x	
Breviarca umbonata Conrad			x
Breviarca saffordi (Gabb) ?		x	
Nemodon sp. nov.		x	x
Arca sp.			x
Barbatia (Polynemà) lintea Conrad		x	
Glycymeris? sp. nov. ?		x	x
Gervilliopsis ensiformis (Conrad)		x	x
Perna sp. nov.	x		x
Inoceramus sp.	x	x	x
Inoceramus sp. (large cast)		x	
Pteria petrosa (Conrad)			x
Ostrea plumosa Morton		x?	x
Ostrea sp. nov. (same as sp. nov. from Blue Banks Landing, N. C.)		x	
Gryphaea sp. (small)			x
Exogyra ponderosa Roemer	x	x	x
Trigonia eufauensis Gabb	x	x?	
Pecten burlingtonensis Gabb			x
Pecten argillensis Conrad ?		x?	
Lima sp. (cf. reticulata Forbes)	x	x	
Anomia argentaria Morton			x
Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.)	x	x	x
Liopistha sp.			x
Veniella conradi (Morton)	x	x	x
Etea carolinensis Conrad	x	x	x
Venericardia ?	x		
Crassatellites sp. (cf. C. carolinensis Conrad)	x	x	x
Arena carolinensis Conrad			x
Lucina sp. nov. ?	x	x	x
Cardium alabamense Gabb	x	x	
Cardium eufaulense Conrad	x		
Cardium spillmani Conrad		x	x
Cardium (two undetermined species)			x
Isocardia sp.			x
Cyprimeria depressa Conrad	x	x	x
Aphrodina regia Conrad ? (young indiv.)	x	x	



A. CUT OF SEABOARD AIR LINE RAILWAY AT MANTA STATION, CHATTAHOOCHEE COUNTY. STRATA OF THE CUSSETA SAND MEMBER OVERLAIN BY MARINE MATERIALS OF THE RIPLEY FORMATION.



B. CUT ON SEABOARD AIR LINE RAILWAY, THREE MILES EAST OF CUSSETA, SHOWING WEATHERED SAND AND LAMINATED CLAY BEDS OF THE CUSSETA SAND MEMBER OF THE RIPLEY FORMATION.

	Locality Numbers		
	T.W.S. 844	L.W.S. 5392	L.W.S. 6405
Aphrodina sp. ?	x		x
Cyclothyris alta Conrad ?	x	x	
Legumen planulatum (Conrad)	x	x	x
Linearia sp. (cf. L. carolinensis Conrad)			x
Linearia sp.	x		
Leptosolen biplicata Conrad			x
Schizodesma appressa Gabb	x		
Corbula crassiplica Gabb		x	x
Corbula carolinensis Conrad	x	x	x
Corbula (otner species)	x	x	x
Dentalium ripleyanum Gabb		x	x
Cadulus obnutus Conrad		x	
Astralium ?		x	x
Capulus ?			x
Lunatia obliquata M. & H.			x
Gyrodes, sp.		x	
Turritella quadrilira Johnson		x	x
Turritella sp.		x	
Turritella sp.		x	
Pterocerella tippana (Conrad) ?			x
Anchura decemlirata Conrad ?		x	
Anchura sp.			x
Nautilus sp. nov. (large)		x	x
Placenticeras ?		x	x
Scaphites ?			x
Arthropoda:			
Crabs claws		x	
Vertebrata:			
Lamna texana Roemer		x	
Vertebrae of fish		x	x

About one mile below Blufftown, in materials similar to those composing layers Nos. 1 and 2 at that place, the following species were collected:

Locality No. 5393.—One mile below Blufftown, Ga., 32 miles below Columbus, Ga. L. W. Stephenson, collector.

Mollusca:
- Cucullaea carolinensis Gabb ?
- Ostrea, sp.
- Pecten sp.
- Etea carolinensis Conrad
- Aphrodina regia Conrau ? (young)
- Legumen planulatum Conrad

From Blufftown to Omaha, 37 miles below Columbus, the materials appearing in the bluffs are similar to those in layers Nos. 1 and 2 of the section at Blufftown. They consist of compact, calcareous sands and clays with indurated, calcareous layers two to 10 feet apart. These layers are nearly horizontal, but are seen to undulate slightly, in places to the extent of several feet of vertical distance. There is,

however, a slight general dip down stream, amounting perhaps to several feet to the mile.

About one-eighth of a mile below the bridge of the Seaboard Air Line Railway at Omaha, the following fossils were collected in a layer five to eight feet above water level:

Loc. No. 5394.—One-eighth mile below Omaha Bridge (S. A. L.) and about 37 miles below Columbus, Ga. L. W. Stephenson, collector.

Vermes:
- Serpula sp.

Mollusca:
- Nucula percrassa Conrad ?
- Cucullaeae sp.
- Nemodon ?
- Trigonia eufalensis Gabb ?
- Pecten burlingtonensis Gabb
- Cymella bella Conrad
- Veniella conradi (Morton)
- Crassatellites sp.
- Cardium (Trachycardium) alabamense Gabb ?
- Cyprimeria depressa Conrad
- Cyclothyris alta Conrad
- Cyclothyris carolinensis Conrad ?
- Legumen planulatum Conrad
- Corbula carolinensis Conrad
- Turritella trilira Conrad
- Tudicla (Pyropsis) perlata Conrad ?
- Gyrodes ?

Vertebrata:
- Otodus appendiculatus Agassiz

Marine materials with indurated, calcareous, concretionary layers, referable to this division, were observed for two miles below Omaha, to the bend to the left below the mouth of Hatchachubbee Creek, 39 miles below Columbus. At the latter place there is a decided reverse dip to the stratification planes amounting to several degrees. The Tombigbee sand member is believed to pass finally beneath water level between this point and Florence, three miles below, for at the latter place beds referable to the Ripley formation make up the entire Cretaceous portion of the bluff.

East of Chattahoochee River.—The Tombigbee member of the formation outcrops in a belt only a few miles wide, extending from Chattahoochee River in a northeasterly direction through Chattahoochee County into Marion County. In the latter county the member probably loses its identity as a massive, calcareous, marine formation, by horizontal mergence into coarser sands and clays of shallow-water origin.

In Chattahoochee County the member has been studied at several places east of the river. The following section was made along the Columbus-Lumpkin road, just north of Jamestown:

Section Columbus-Lumpkin Road, northward-facing slope of Sand Branch, 18 miles south of Columbus, near Jamestown postoffice.

	Feet.
Upper Cretaceous.	
Ripley formation (*Exogyra ponderosa* zone).	
12. Reddish, massive, medium-grained, ferruginous, marine sand, partially indurated	5

11.	Coarse, reddish and yellowish, loose sand	3
10.	Fine, micaceous, unconsolidated sand, streaked with yellow and purple	20
9.	Dark, laminated, finely micaceous clay	6 in. to 1
8.	Fine, micaceous, greenish gray, argillaceous, marine sand filled with soft pelecypod casts, with some lenses of unfossiliferous, gray sand, and a thin layer of dark, laminated clay, two feet above base	10
7.	Greenish gray, argillaceous sand with numerous small, short, interlocking clay laminae	6
6.	Dark, finely-arenaceous, thinly laminated clay	12
	Eutaw formation (Tombigbee sand member, *Exogyra ponderosa* zone).	
5.	Greenish gray, argillaceous, massive sand, with numerous soft casts	5
4.	Dark, laminated, micaceous clay interstratified with lenses and layers of light greenish gray, fine, micaceous sand reaching a maximum thickness of three feet. Some fossil casts	17
3.	Dark greenish gray, extremely micaceous sand with occasional calcareous concretions. Contains an abundance of decayed fossil shells	11
2.	Similar to layer No. 3, but light greenish gray in color. Contains soft shells	10
1.	Poorly exposed to base of hill, but consists for the most part of greenish gray, massive, non-fossiliferous marine sand	22

The dividing line between the Eutaw and Ripley formations has been placed rather arbitrarily at the point indicated in the above section, and future work may demonstrate the necessity of placing it at some other level.

The fossils given in the list below were obtained from layers Nos. 2 and 3.

Locality No. 6411 a-b.—Columbus-Lumpkin road, south side, about 18 or 18½ miles south of Columbus, Ga. L. W. Stephenson, collector.

Mollusca:
- Nucula sp. (cf. sp. nov. from Snow Hill, N. C.)
- Exogyra ponderosa Roemer
- Trigonia eufalensis Gabb
- Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.)
- Veniella sp. (cf. species from Hodges Mill, S. C.)
- Cyprimeria depressa Conrad
- Cymbophora lintea (Conrad)
- Schizodesma appressa Gabb ?
- Corbula carolinensis Conrad
- Turritella quarrilira Johnson

Another exposure of the member is furnished by a cut of the Seaboard Air Line Railway, two and one-half miles northwest of Cusseta at the 16th milepost (south of Columbus). The materials consist of about 10 feet of dark gray, marine sand, with a layer of nodular lime concretions near the base. (See plate XII, B, opposite page 128.) The lower two or three feet, including the concretions, is fossiliferous. The determinable forms are listed below:

Locality No. 5379.—Two and one-half miles northwest of Cusseta, Ga., in cut of Seaboard Air Line Railway, Milepost 16. L. W. Stephenson, collector.

Mollusca:
- Cucullaea sp.
- Inoceramus sp.
- Inoceramus sp.
- Breviarca sp.
- Exogyra ponderosa Roemer
- Exogyra ponderosa var. erratistata Stephenson
- Pecten sp. nov. (cf. sp. nov. from Snow Hill, N. C.)
- Anomia argentaria Morton
- Liopistha alternata Weller
- Veniella conradi Morton
- Etea carolinensis Conrad
- Lucina glebula Conrad
- Cardium sp. (cast)
- Cardium alabamense Gabb ?
- Cyprimeria depressa Conrad
- Aphrodina sp.
- Corbula carolinensis Conrad
- Turritella trilira Conrad

One-half mile northwest of Cusseta on the same railroad, the following forms were obtained in the form of casts, from a black clay at the base of a cut:

Locality No. 5380.—One-half mile northwest of Cusseta, Ga., in cut of Seaboard Air Line Railway. L. W. Stephenson, collector.

Mollusca:
- Cymella bella Conrad
- Schizodesma appressa Gabb
- Undetermined pelecypod casts

This horizon is near the top of the Tombigbee sand and probably occupies approximately the same stratigraphic position as the fossiliferous layers Nos. 2 and 3, in the section near Jamestown described on p. 114 of this report.

The Tombigbee sand, as such, has not been traced with certainty far beyond the boundary of Chattahoochee County into Marion County. Veatch has noted an exposure of black micaceous clay near the western border of the latter county which is believed to represent this division. It is believed that the massive, marine beds disappear in Marion County by horizontal mergence into irregularly bedded sand and clays of shallow-water origin.

CORRELATION

The present attempt to establish the age and geological position of the beds here referred to the Eutaw formation, in terms of better known sections outside of Georgia, is made partly on the basis of their contained animal and plant remains, and partly on the basis of their stratigraphic position with reference to overlying beds, the paleontologic characters of which are such as to permit of more accurate correlations.

The studies furnishing the paleontologic data for correlation have been of a preliminary character and it is to be expected that the exhaustive studies of the fauna of the region soon to be prosecuted will

show the necessity for many changes in nomenclature of the fossils, and will reveal some errors in the determinations of genera and species. It is also to be expected that some species now regarded as restricted in range within certain limits will be found to occur in higher or in lower horizons. But this lessening of the number of restricted forms will probably be offset by the discovery of new restricted forms, and by the recognition of specific differences in forms now regarded as having wide vertical ranges. It is believed, however, that such changes as are found necessary will be of minor importance as regards their effect upon the major conclusions reached through these preliminary studies.

The lists of Eutaw species from Chattahoochee River and from Georgia, given on preceding pages, fall into two sets: first, those from horizons in the lower 100 or 150 feet of the formation; and second, those from the Tombigbee sand member which makes up the upper 120 feet of the formation. The two sets will be considered separately.

Basal beds of the formation.—The following species of invertebrate fossils, 16 in number, have been identified from the beds composing the lower 100 or 150 feet of the formation:

Nucula percrassa Conrad
Perna sp. nov.
Ostrea cretacea Morton
Ostrea sp. nov. (cf. sp. nov. from House Bluff, Alabama River.)
Ostrea sp. nov. ? (aff. O. lugubris Conrad)
Exogyra upatoiensis Stephenson
Pecten sp. nov. (same as at Snow Hill, N. C.)
Anomia sp. nov. (same as at Snow Hill, N. C.)
Pholadomya sp. nov.
Etea carolinensis Conrad
Cyprimeria depressa Conrad
Baroda sp. nov.
Leptosolen biplicata Conrad
Cymbophora lintea (Conrad)
Corbula carolinensis Conrad
Placenticeras sp. (aff. P. guadalupae Roemer)

Of the species listed the following five range upward through the Tombigbee sand and the Ripley formation, and are, therefore, of no value in close correlation:

Nucula percrassa Conrad
Etea carolinensis Conrad
Cyprimeria depressa Conrad
Leptosolen biplicata Conrad
Cymbophora lintea (Conrad)

Corbula carolinensis Conrad ranges up into but not above the zone of *Exogyra ponderosa* of the Ripley formation. In North Carolina *Corbula carolinensis* is found in the invertebrate-bearing beds of the upper part of the Black Creek formation. In New Jersey a nearly related, if not identical form, *Corbula bisulcata* Conrad, occurs in the Magothy formation ("Cliffwood clay"), and in the Merchantville clay marl and the Woodbury clay (basal formations of the Matawan). In western Alabama it occurs in the Eutaw formation at Finches

Ferry, and in Mississippi five and one-half miles east of Booneville, in glauconitic sands which fall within the zone of *Exogyra ponderosa*. The species is of value therefore, only as indicating an age greater than that of the extreme basal beds of the zone of *Exogyra costata*.

In the Chattahoochee region *Ostrea cretacea* Morton occurs sparingly in the overlying Tombigbee sand. It is abundant, however, in the Tombigbee sand in central and western Alabama. In North Carolina the species occurs abundantly at Kerrs Cove, Black River, and sparingly at a number of other localities in the Black Creek formation. From the evidence furnished by other forms it is believed that these Black Creek localities correspond in stratigraphic position to that part of the zone of *Exogyra ponderosa* which lies above the Tombigbee sand in the Chattahoochee region. In New Jersey the species occurs in the Magothy formation. This form appears, therefore, to have about the same range, and consequently the same significance, as *Corbula carolinensis*.

Pecten sp. nov. and *Anomia* sp. nov. range up through the Tombigbee sand into the basal beds (*Exogyra ponderosa* zone) of the Ripley formation. Both occur in the marine invertebrate-bearing beds of the Black Creek formation in North Carolina. *Ostrea* sp. nov. (probably same as sp. nov. from House Bluff, Alabama River) is questionably referred to an undescribed species occurring in abundance at the top of the Tombigbee sand at House Bluff, Alabama River, Ala. *Perna* sp. nov. ranges up into the Tombigbee sand. This species is not known outside of the Chattahoochee region, although representatives of the genus occur in the Black Creek formation of North Carolina. *Ostrea* sp. nov.? (aff. *O. lugubris* Conrad) is new to the eastern Gulf Cretaceous. *Ostrea lugubris* Conrad,[1] with which it is compared, is known only from the Eagle Ford formation of Texas. *Placenticeras* sp. (cf. P. *guadalupae* Roemer) appears to be closely related to, but is not identical with *Placenticeras guadalupae* Roemer, a form common in the Tombigbee sand (*Mortoniceras* horizon), and in the upper part of the Austin chalk of Texas.

Exogyra upatoiensis Stephenson,[1] *Philadomya* sp. nov., and *Baroda* sp. nov. have not been found outside of the basal beds of the Eutaw formation in the Chattahoochee region.

To summarize, five of the 16 species range upward into the *Exogyra costata* zone of the eastern Gulf region, and 11 are restricted below that zone and its equivalents. Of the 11 restricted forms four range upward into the basal beds of the Ripley formation (*Exogyra*

[1]Since this report was written, good specimens of an oyster closely related to *Ostrea lugubris* Conrad, and good specimens of *Exogyra upatoiensis* Stephenson, have been recognized in well samples obtained from a deep well at Charleston, S. C., at depths of between 1,974 and 2,007 feet. The horizon from which they were taken doubtless corresponds in age to the horizon which has yielded the fauna of the basal beds of the Eutaw formation in the Chattahoochee region.

ponderosa zone), two range into the Tombigbee sand, and five are restricted to the basal Eutaw beds.

The basal Eutaw beds lack entirely the species which are regarded as characeristic of the *Exogyra costata* zone. They also lack certain species which are common in the *Exogyra ponderosa* zone, which includes the Tombigbee sand and a part of the overlying Ripley formation, such as *Exogyra ponderosa* Roemer and *Gryphaea aucella* Roemer. The five forms restricted to the beds of this formation, since they are all new to science, afford but little positive evidence of the age of the terrane. However, the beds in which they are found are known to occupy a position stratigraphically lower than any other marine invertebrate-bearing beds thus far discovered in the eastern Gulf region, and, for this reason if for no other, the fauna must be regarded as the oldest of its kind known in the region. The new species, *Exogyra upatoiensis* Stephenson, which occurs in the marine beds near the base of the formation, has a markedly different surface sculpture from the other known species of this genus in the Atlantic and Eastern Gulf Cretaceous. The presence of this species and the presence of the fluted oyster, related to *Ostrea lugubris* Conrad, which occurs in the Eagle Ford formation of Texas, may perhaps be considered paleontologic evidence of the greater age of the fauna. Since the conditions of the preservation of one species of oyster are as favorable as they are for the preservation of any other species of the same family, this new species of *Exogyra* and the fluted oyster would be expected to appear in the collections from the overlying Tombigbee sand if, in this region, they had lived contemporaneously with the oyster, *Exogyra ponderosa* Roemer, which is common in that terrane.

From the range determinations as above stated, the following conclusions have been deduced: The fauna present in the basal beds of the Eutaw formation possesses elements in common with the Cretaceous faunas of higher horizons in the same region; however, in passing from this basal horizon to the successively higher horizons the number of common species diminishes. Although showing these relationships the fauna contains elements distinct from anything known in the higher horizons. Comparing this fauna with Cretaceous faunas to the northward it is found that it bears about the same relationship to the invertebrate fauna present in the upper part of the Black Creek formation of the Carolinas that it does to the fauna of the basal beds of the Ripley formation (*Exogyra ponderosa* zone) in the Chattahoochee region. The basal Eutaw beds are therefore lower, stratigraphically, than the invertebrate-bearing beds of the Black Creek formation, and, in the opinion of the writer, correspond approximately to the non-invertebrate bearing beds of that formation. The actual evidence for a comparison of the basal Eutaw fauna with

the Cretaceous faunas of New Jersey is slight, but combined with evidence furnished by the faunas from overlying horizons there seems to be sufficient grounds for correlating the containing strata approximately with the Magothy formation.

The invertebrate-bearing basal Eutaw beds of the Chattahoochee region are represented to the westward in Alabama and Mississippi by corresponding basal Eutaw strata in which no well-preserved invertebrates have as yet been discovered.

Fossil plants have been obtained at several horizons in that part of the Eutaw formation below the Tombigbee sand member. E. W. Berry, who studied them, recognized 27 species from the terrane. He furnishes the following statements, quoted from an unpublished manuscript on the fossil plants of Georgia, giving his views of the significance of the plant remains in correlation:

> It is clear that the flora of the Eutaw formation of Georgia is of the same age as the Magothy flora of the northern Coastal Plain and the Black Creek flora of the Carolinas. It has much in common with the much more extensive Tuscaloosa flora of western Alabama, and these beds of Georgia are probably homotaxial with more or less of the upper Tuscaloosa of western Alabama. Whether the Tuscaloosa flora of western Alabama is essentially a unit and accidents of preservation account for its greater richness, or whether the plant beds of this fromation in northwestern Alabama are appreciably older, is a question which can not be answered positively until the flora is critically studied.
>
> The flora of the Eutaw in Georgia is strictly comparable with that of the upper Tuscaloosa of western Alabama, as for example, the flora of which a few species are preserved near Havana in Hale County, Ala., and which lies on the border line between the Tuscaloosa and Eutaw formations, as delimited in that area by Professor Smith, the State Geologist.

The evidence furnished by the plants as interpreted is at least in part agreement with that afforded by the invertebrates, although in the opinion of the present writer the Magothy flora, with which Georgia flora is compared, persisted to a later time in the region of the Carolinas, and, as will be shown later, also in Georgia, than in New Jersey; for the fauna present in the upper part of the Black Creek formation seems to indicate clearly that this terrane includes representatives of both the Magothy and the overlying Matawan formations.

The flora in the upper part of the Tuscaloosa formation in Hale County, Ala., with which Berry compares these Georgia species, occurs in beds the lithologic character of which would admit of their being considered as belonging to either the upper part of the Tuscaloosa formation, or to the basal portion of the overlying Eutaw formation.

The following vertebrate species, all sharks, have been collected from the Broken Arrow Bend exposure near the base of the Eutaw formation:

Corax falcatus Agassiz
Lamna texana Roemer
Otodus appendiculatus Agassiz

As these species are all known to have a wide stratigraphic range they have no value in close correlation.

Tombigbee sand member.—The beds on Chattahoochee River, here referred to the Tombigbee sand, are so correlated chiefly on the evidence of certain species of invertebrates, but in part upon their physical characters and relations. Lithologically, the materials agree in all essential respects with those of the type region in Mississippi, although the content of lime is greater. The formation is immediately underlain by sands and clays containing a considerable percentage of lignite and in this respect the lower relations are in exact agreement with those of the type region. In the type region the Tombigbee sand is immediately overlain by the Selma chalk. In the Chattahoochee region the Selma chalk is not present as such, but is represented by marine sands and clays, the beds immediately above the Tombigbee sand being of marine origin and similar to the beds of the Tombigbee member itself.

The Tombigbee sand member forms the basal portion of the zone of *Exogyra ponderosa* of the Upper Cretaceous deposits, of which the lower one-third or one-half of the Ripley formation forms the upper part.

Omitting a number of questionably identified species, 57 species of invertebrates have been identified from the Tombigbee member in the Chattahoochee region as follows:

1. **Serpula sp. (nearly straight tube) (Rc)**
2. **Hamulus onyx Morton (Rc, Rp)**
3. **Hamulus major Gabb**
4. **Nucula percrassa Conrad (Rc, Rp, Eb)**
5. **Nucula eufalensis Gabb (Rc)**
6. **Nucula sp. (cf. sp. nov. from Snow Hill, N. C.)**
7. **Leda longifrons Conrad (Rc)**
8. **Perrisonota protexta Conrad (Rc)**
9. **Cucullaea carolinensis (Gabb) (Rp)**
10. **Breviarca umbonata (Conrad)**
11. **Nemodon sp. nov. (Blufftown, etc.)**
12. **Barbatia lintea Conrad (Rp)**
13. **Gervilliopsis ensiformis (Conrad) (Rc)**
14. **Perna sp. nov. (Broken Arrow Bend, etc.) (Ec)**
15. **Ostrea plumosa Morton (Rc, Rp)**
16. **Ostrea cretacea Morton (Eb)**
17. **Ostrea sp. nov. (same as at Blue Banks Ldg., N. C.)**
18. **Gryphaea ancella Roemer**
19. **Exogyra ponderosa Roemer**
20. **Exogyra ponderosa var. erraticostata Stephenson (Rp)**
21. **Trigonia eufalensis Gabb (Rc)**
22. **Pecten quinquecostatus (Sowerby) (Rc)**
23. **Pecten simplicius Conrad (Rc)**
24. **Pecten burlingtonensis Gabb (Rp)**

25. Pecten sp. nov. (same as sp. nov. from Snow Hill, N. C.) (Rp. Eb.)
26. Lima reticulata Forbes (Rc)
27. Anomia argentaria Morton (Rc, Rp)
28. Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.) (Rp, Eb)
29. Cymella bella Conrad (Rc)
30. Liopistha alternata Weller
31. Liopistha sp. (aff. F. alternata Weller)
32. Veniella conradi (Morton) (Rc, Rp)
33. Etea carolinensis Conrad (Rc, Eb)
34. Vetericardia crenalirata (Conrad) (Rc)
35. Crassatellites carolinensis Conrad ? (Rp)
36. Arena carolinensis Conrad
37. Lucina glebula Conrad (Rp)
38. Cardium eufaulense Conrad (Rc, Rp)
39. Cardium spillmani Conrad (Rc)
40. Cardium alabamense Gabb (Rc)
41. Cyprimeria depressa Conrad (Rc, Rp, Eb)
42. Cyclothyris alta Conrad (Rp)
43. Legumen planulatum (Conrad) (Rc, Rp)
44. Linearia metastriata Conrad (Rc)
45. Leptosolen biplicata Conrad (Rc, Rp, Eb)
46. Cymbophora lintea (Conrad) (Rc, Rp, Eb)
47. Schizodesma appressa Gabb
48. Corbula crassiplica Gabb (Rc)
49. Corbula carolinensis Conrad (Rp, Eb)
50. Dentalium ripleyanum Gabb (Rc)
51. Dentalium sp. nov. (same as sp. nov. from Owl Creek, Miss)
52. Cadulus obnutus (Conrad) (Rc)
53. Lunatia obliquata Meek and Hayden (Rc)
54. Turritella trilira Conrad (Rc)
55. Turritella quadrilira Johnson
56. Nautilus sp. nov. (large, Blufftown, etc.)
57. Mortoniceras sp. nov. (cf. M. texanum Roemer)

Of the 57 species, 30, marked (Rc) in the list, have been recognized in the zone of *Exogyra costata* of the Ripley formation in the Chattahoochee region; 20, marked (Rp), in the zone of *Exogyra ponderosa* of the Ripley formation; and 10, marked (Eb), in the underlying basal beds of the Eutaw formation. The questionably identified form, *Crassatellites carolinensis* Conrad, although not certainly identical with the species described by Conrad from Snow Hill, belongs to a flat type of the genus which does not appear to range above the zone of *Exogyra ponderosa,* and is included in the preceding list because of the value in correlation which this restriction in range gives it.

The 30 species which have been found as high as the zone of *Exogyra costata* need not be further considered since their great vertical range renders them of no value in the finer discrimination of age relationships. Twenty-seven of the 57 species are in this region restricted below the zone of *Exogyra costata* of the Ripley formation. The table given below indicates the range of these 27 species, both within and without the Chattahoochee region.

Table showing ranges of the Tombigbee species which in the Chattahoochee region are restricted below the zone of Exogyra costata.

	Basal beds of Eutaw formation in the Chattahoochee region.	*Exogyra ponderosa* zone of the Ripley formation in the Chattahoochee region.	Tombigbee sand member (*Mortoniceras* sub-zone) west of Chattahoochee region in Alabama and east-central Mississippi.	*Exogyra ponderosa* zone above *Mortoniceras* sub-zone, west of Chattahoochee region in Alabama and Mississippi.	*Exogyra costata* zone of northern Mississippi.	Black Creek formation of the Carolinas.	Magothy formation of New Jersey.	Matawan group of New Jersey.
Hamulus major Gabb				x		x		
Nucula sp. nov. (cf. sp. nov. from Snow Hill, N. C.)				x		x		
Cucullaea carolinensis Gabb		x		x?		x		
Breviarca umbonata (Conrad)								
Nemodon sp. nov. (Blufftown, etc.)								
Barbatia lintea Conrad		x	x?			x		
Perna sp. nov. (Broken Arrow Bend, etc.)	x							
Ostrea cretacea Morton	x		x	x		x	x	
Ostrea sp. nov. (same as sp. nov. from Blue Banks Landing, N. C.)				x		x		
Gryphaea aucella Roemer			x	x				
Exogyra ponderosa Roemer			x	x		x		x[1]
Exogyra ponderosa var. erraticostata Stephenson		x	x	x		x		
Pecten burlingtonensis Gabb		x		x		x		x[2]
Pecten sp. nov. (same as sp. nov. from Snow Hill, N. C.)	x	x	x			x		
Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.)	x	x	x	x		x		
Liopistha alternata Weller			x					x[3]
Liopistha sp. nov. (aff. L. alternata Weller)			x					
Crassatellites carolinensis Conrad		x	x?			x		
Arena carolinensis Conrad						x		
Lucina glebula Conrad		x	x?	x?		x		
Cyclothyris lata Conrad		x		x		x		
Schizodesma appressa Gabb				x	x	x	x	x[4]
Corbula carolinensis Conrad	x	x				x	x	x[5]
Dentalium sp. nov. (same as sp. nov. from Owl Creek, Miss.)					x			
Turritella quadrilira Johnson			x			x	x	x[6]
Nautilus sp. nov. (large, Blufftown, etc.)			x					
Mortoniceras sp. (aff. M. texana Roemer and M. delawarensis Morton)			x					x[7]

[1]Occurs in the Marshalltown clay-marl of the Matawan formation.
[2]Occurs in the Merchantville clay-marl, the Woodbury clay, and the Wenonah sand of the Matawan formation.
[3]Occurs in the Merchantville clay-marl of the Matawan formation.
[4]Occurs in the Wenonah sand of the Matawan formation.
[5]Probably same as *Corbula bisulcata* Conrad which occurs in the Magothy formation, and the Merchantville clay-marl and the Woodbury clay of the Matawan formation.
[6]Occurs in the Woodbury clay of the Matawan formation.
[7]Occurs in the Merchantville clay-marl of the Matawan formation.

Of the 27 species given in the table 10 occur in that part of the overlying Ripley formation included within the zone of *Exogyra ponderosa,* five occur beneath the Tombigbee sand in the basal beds of the Eutaw formation, and 15 are restricted to the Tombigbee sand member.

To the westward of the Chattahoochee region in Alabama and Mississippi, seven of the 15 restricted species are known to occur in the *Mortoniceras* sub-zone of the Tombigbee sand, seven are known in that part of the zone of *Exogyra ponderosa* overlying the *Mortoniceras* sub-zone, and two in the zone of *Exogyra costata* (Ripley formation of northern Mississippi). The small number of forms common to the Tombigbee sand of the Chattahoochee region, and to the same member to the westward in Alabama and Mississippi, is to be explained by the fact that in the Chattahoochee region the member is far more prolific in species than elsewhere in the eastern Gulf region; and this palentologic difference appears to be reflected in the lithology, in that the Tombigbee of the Chattahoochee region contains a much higher percentage of calcite than does the typical Tombigbee to the westward.

The forms that are believed to indicate the correspondence in age of the beds under consideration with the Tombigbee sand to the westward in Alabama, and in the type region in Mississippi, are the following: *Liopistha alternata* Weller, *Nautilus* sp. nov. (large), and *Mortoniceras* sp. (aff. *M. texana* Roemer).

These forms are not known above the *Mortoniceras* sub-zone in the region, and the *Nautilus* and *Mortoniceras* are distributed generally in this horizon from Montgomery, Ala., to Aberdeen, Miss. It is considered probable that the genus *Mortoniceras* does not occur in the Atlantic and Gulf Coastal Plain in beds higher than this horizon.

Of the 15 species restricted to the Tombigbee sand in the Chattahoochee region, seven occur in the invertebrate-bearing beds forming the upper part of the Black Creek formation of the Carolinas, and none in the Peedee sand. The three specimens given above as characteristic of the Tombigbee sand, however, have not been found in the Black Creek beds, and their absence together with the fact that the Black Creek fauna corresponds closely to that of the overlying *Exogyra ponderosa* zone of the Ripley formation in the Chattahoochee region, is taken as evidence that the Tombigbee sand is slightly lower stratigraphically than the invertebrate-bearing Black Creek beds, or, in other words, that it is represented by a part of the non-invertebrate-bearing beds of the Black Creek formation below the beds carrying invertebrates.

Of the 15 forms restricted to the Tombigbee sand member in the

Chattahoochee region, two occur in the Magothy formation and four in the Matawan group of New Jersey. Of the four occurring in the Matawan group one, *Liopistha alternata* Weller, occurs only in the Merchantville clay marl, the basal formation of the group. *Mortoniceras* is represented in the New Jersey Cretaceous by *Mortoniceras delawarensis* (Morton), which is restricted to the Merchantville clay marl. The presence in this formation of *Liopistha alternata* Weller, and the presence of *Mortoniceras* which in the eastern Gulf Cretaceous is not known to range above the Tombigbee sand member, are considered evidence that the formation is approximately synchronous with the Tombigbee sand member of the Eutaw formation. It will be observed that not one of the 15 restricted forms occur in the Monmouth formation of New Jersey.

Three species of vertebrate animals have been recognized from the Tombigbee sand of the Chattahoochee region. These are teeth of the sharks, *Corax falcatus* Agassiz, *Lamna texana* Roemer, and *Otodus* sp.? The two former are wide-ranging forms and are of no correlative value, and the latter is not sufficiently well identified for its value in correlation to be known.

The conclusions deduced from the above statements of range may be summarized as follows:

The Tombigbee sand of the Chattahoochee region while containing many species in common with the overlying Ripley beds, nevertheless contains a few forms of restricted vertical range and extended geographic range, possessing great value in close correlation. On the evidence of these few forms the Tombigbee sand member of the Eutaw formation in the Chattahoochee region is correlated with the Tombigbee sand of the type region in Mississippi, and especially with the *Mortoniceras* sub-zone of that member. Referred to the Carolina Cretaceous the member is believed to be synchronous with a portion of the Black Creek formation beneath the invertebrate-bearing beds of that formation. In New Jersey the Merchantville clay marl is believed approximately to represent the Tombigbee member.

A diagrammatic representation of the age relationships of the Eutaw beds of the Chattahoochee region to Cretaceous deposits elsewhere in the eastern Gulf region and the Atlantic Coastal Plain, is given in Plate V.

RIPLEY FORMATION

NAME

The name Ripley is derived from the town of Ripley, in Tippah County, Miss., and was originally proposed as the name of a geologic division by Dr. Eugene W. Hilgard[1] in 1860. The town of Ripley

[1]Geology and agriculture of the State of Mississippi: Jackson, Miss., 1860, pp. 62, 83-95.

is situated upon Eocene strata which were erroneously referred by Hilgard to the Cretaceous. However, Cretaceous beds appear in the banks of Tippah Creek within one-half mile of town, where they are overlain by Eocene (Midway) limestone. This error was corrected by G. D. Harris[1] in 1896. Layers 1, 2, and 3 of the section given by Hilgard,[2] on Tippah Creek near Ripley, belong to the Cretaceous. Concerning the distribution of the beds of this formation Hilgard says:

"These strata from the Pontotoc Ridge in Mississippi, and Chunnenugga Ridge in southeast Alabama; according to the late researches by Conrad, they also exist at Eufaula, Ala."

Exposures of Ripley strata in the bluffs of Owl Creek, three miles northeast of Ripley, have been rendered classic by the paleontologic researches of T. A. Conrad.[3]

Although the equivalency of the Cretaceous beds exposed on Chattahoochee River at Eufaula, to the Cretaceous beds in Tippah County, Miss., was recognized by Conrad[4] in 1860, the first investigator to refer this whole series of Ripley beds along the Chattahoochee River to this division was D. W. Langdon.[5] He included in his Ripley group an additional 120 feet of strata at the base of the series which in this report are, on paleontologic evidence, referred to the Tombigbee member of the underlying Eutaw formation.

DEFINITION.

Areal distribution.—The Ripley formation is exposed on Chattahoochee River in the upper part of the bluff at Blufftown, thirty-one and one-quarter miles below Columbus, Ga., and in the bluffs from Florence, in Stewart County, Ga., to a point not accurately determined near Othos Landing, Ala., about 15 miles below Eufaula. It extends northeastward from the river through Georgia in a belt 10 to 14 miles wide, including parts of the following counties: Clay, Quitman, Stewart, Webster, Chattahoochee, Marion, Schley, Taylor, Macon, Crawford, Houston, Bibb, and Twiggs. In Twiggs, Houston, southwestern Crawford, and eastern Macon counties, the formation is concealed by a relatively thin blanket of overlapping younger strata, referable in part, or perhaps in whole, to the Eocene epoch, except where the latter have been removed by stream erosion.

West of Chattahoochee River in Alabama the formation appears in an area south of that occupied by the Eutaw formation, having a maximum width of 25 or 30 miles, and including parts of Russell,

[1]The Midway stage: Bull. Amer. Paleon., Vol. 1, No. 4, 1896, pp. 22-25 (136-139).
[2]Geology and agriculture of the State of Mississippi; Jackson, Miss., 1860, p. 87.
[3]Observations on a group of Cretaceous fossil shells, found in Tippah County, Miss., with descriptions of fifty-six new species: Jour. Acad. Nat. Sci. Phila., n. s., vol. 3, 1855-58, pp. 323-336, plates 34 and 35.
[4]Jour. Acad. Nat. Sci. Phila., n. s. vol. 4, 1858-1860, pp. 275-298.
[5]Bull Geol. Soc. America, vol. 2, 1891, pp. 587-606.

Barbour, Macon, Bullock, Pike, Montgomery, Butler, Lowndes, Dallas, Perry, and Marengo counties. The western boundary of the formation is determined by the horizontal mergence of the beds in that direction into the beds of the Selma chalk.

Stratigraphic position.—In western Georgia and in Alabama the formation rests with conformable relations upon the Eutaw formation. From Taylor County eastward to the eastern limits of its occurrence in Twiggs County, the Ripley beds rest unconformably upon Lower Cretaceous strata. The formation is overlain unconformably in both Alabama and Georgia by Eocene strata. This unconformity is an important one and probably represents a long period of time. This is evidenced by the great faunal change which took place during the interval, few if any species having survived from Cretaceous to Eocene time.

In Macon, Houston, and southeastern Crawford counties the formation is concealed throughout considerable areas in which it would otherwise appear at the surface, by a relatively thin overlap of strata believed to be referable to the Eocene. In Twiggs County the formation passes finally beneath, and is completely overlapped and buried by Eocene deposits.

In narrow areas bordering Chattahoochee, Flint, and Ocmulgee rivers the formation is overlain by thin, surficial terrace deposits of Pleistocene age.

Lithologic characters.—With the exception of portions of the upper parts of the high bluffs at Blufftown and at Stewart's Hill, the materials of this formation exposed in the immediate bluffs of Chattahoochee River are all of a strictly marine character. They consist of massive, dark gray or greenish gray to black, more or less calcareous, micaceous, pyritiferous, and glauconitic sands and clays, with indurated ledges of calcareous sandstone or impure sandy limestone at vertical intervals of a few feet to 10 feet or more, with, in places, interbedded layers of loose, crossbedded, yellowish, calcareous sands and shell marls of shallow marine origin. Fossils are common as shells or shell prints and at various levels are sufficiently abundant to form shell marls. The shallow marine phases contain in places numerous fragmentary bones of dinosaurs, mosausaurs, crocodiles, and turtles, together with occasional reptile teeth, great numbers of sharks' teeth of several species, and a few other fish teeth. In the exposures in the vicinity of Woolridge Landing these vertebrate remains are closely associated with an undescribed species of gigantic oyster, and with a large number of other species of mollusks. To the northeastward away from Chattahoochee River in Georgia, the basal portion

of the formation embracing 200 or 300 feet of strata merges along the strike of the beds into shallow-water equivalents which differ in their essential lithologic characters from the typical beds. This is the Cusseta sand member described below. The uppermost beds of the formation also merge along the strike both to the northeastward in Georgia and to the westward in Alabama into the similar shallow-water equivalents which are later described as the Providence sand member of the formation.

The Cusseta sand member consists of irregularly bedded, unconsolidated sands, with subordinate clay lenses, probably of sound or estuarine origin, but perhaps in part of shallow marine origin. They outcrop at the surface in a belt which includes parts of the following counties: Stewart, Chattahoochee, Marion, Schley, Taylor, Macon, Crawford, Houston, Bibb, and Twiggs. In Stewart and Chattahoochee counties the sands vary from fine to coarse in texture, and are somewhat arkosic. Farther to the northeast in Marion County the materials become in general coarser, although rather fine phases are not uncommon. This same predominance of coarse materials holds true throughout the remainder of the area occupied by the member, but as in Marion County, finer sands are known to occur locally. The clay lenses present in these sands are for the most part light drab, or even white, and massive, and in general resemble the more impure clays of the Lower Cretaceous. Locally, however, the clays are thinly laminated. At a few places carbonaceous clays, both massive and laminated, containing considerable percentages of comminuted plant remains have been noted, and fossil leaves have been collected at two such localities. This non-marine phase of the formation was first discriminated by Otto Veatch[1] in 1909, and was designated by him the Cusseta sand. The division is here given the rank of member. The similarity of the materials of the Cusseta sand member to the shallow-water phase of the Eutaw formation in its eastern extension renders the two formations separable only with difficulty. The same is true of this member with respect to the overlying Providence sand member of the Ripley formation in the region between Flint and Ocmulgee rivers.

The Providence sand member consists predominantly of coarse, irregularly bedded sands with subordinate light-colored clay lenses and layers. In Georgia the member outcrops in a long, narrow belt lying along the southern border of the Cretaceous area, and including parts of Quitman, Stewart, Webster, Marion, Schley, Macon, Houston, and Twiggs counties. In Alabama it is present along the southern

[1]Second report on the clay deposits of Georgia: Bull. Geol. Survey of Ga. No. 18, 1909, pp. 82-90.

border of the Cretaceous area in parts of Barbour, Bullock, and Pike counties.

Although the sands are in general coarse there are finer phases and this is especially true of the beds towards the base of the member, or the zone of transition from the underlying typical marine beds to the overlying coarser beds of this member. Rolled clay balls are numerous at many places in the sands. In Houston County the member contains notable lenses of white clays which have been mined in a small way and which give promise of becoming of commercial importance in the future.

The typical marine beds, the "Renfroes marl" of Veatch, which intervenes between the Cusseta and Providence members, is traceable as a narrow belt from the Chattahoochee region through Stewart, Chattahoochee, Marion, and Schley counties, to Macon County, where they appear to pinch out, so far as surface outcrops are concerned, between the underlying and overlying shallow-water members. Beyond this point to the eastern limit of the surface occurrence of the formation the two members, each of which has gradually increased its thickness in this direction, are in conformable contact with each other, and together appear to represent the whole thickness of the formation. However, there is evidence that buried representatives of the typical marine beds extend eastward, at least as far as Marshallville, where calcareous beds have been penetrated in a well boring. The Providence sand was differentiated and named by Otto Veatch[1] in 1909.

Strike, dip, and thickness.—The beds of this formation have in Georgia a general northeast-southwest strike. To the west in Alabama the strike is nearly due east and west.

That portion of Langdon's[2] Chattahoochee River section, referred in this report to the Ripley formation, includes layers Nos. 14 to 38. the thicknesses given by him total 948 feet. The beds outcrop at zero water level along the river in an air-line distance across the strike of about 29 miles. The average dip required to produce in this distance the thickness estimated by Langdon is 32 feet to the mile. In order to determine the correct average dip it would be necessary to make a large number of dip observations. It is known, however, that the beds undulate, the dip being less in places and elsewhere amounting to as much as 40 feet to the mile. In the absence of the data necessary for an accurate calculation of the thickness, Langdon's figure may be regarded as a probable close approximation to the true amount.

[1]Op. cit., pp. 82-90.
[2]Geological Survey of Alabama, Geology of the Coastal Plain of Alabama, 1894, pp. 439-445.

A well at Buena Vista, Marion County, penetrated strata believed to be referable to this information, to a depth of 583 feet. No other wells properly located, or of sufficient depth, to give an idea of the thickness of the terrane, have been drilled along the belt of its occurrence, but it is probable that it maintains approximately this thickness to the eastern limits of its areal extent. However, to the south of the belt of outcrop at Albany, in Dougherty County, Ga., Tertiary and Cretaceous strata were penetrated in a well to a depth of 1,320 feet. The upper 500 feet of the section is referred to the Tertiary. The remainder of the strata, 820 feet, should probably be referred in their entirety to the Ripley formation. Besides the Albany well a well at Blakely, Early County, drilled to a depth of 812 feet, passed entirely through the overlying Tertiary strata and entered the Ripley formation at less than 500 feet below the surface, the exact depth at which the Ripley was first encountered, however, being unknown.

Physiographic expression—The general upland surface throughout the areal extent of this formation is a dissected plain, ranging from 400 to 600 feet above sea level. Topographically the region may be said to have advanced to the stage approaching that of maturity, the surface, therefore, being broken and hilly. The formation througout the greater part of its areal extent in Georgia is composed predominantly of beds of a sandy character. A thin, surficial blanket of loose, gray sand, resulting from the weathering and leaching of these sand beds, is almost universally present. In Macon, Crawford, and Houston counties the formation is concealed over considerable areas by a thin overlap of red, ferruginous sand of probably Eocene age. Where the latter is present, and especially in the region surrounding Fort Valley, the surface is remarkably level, and is in strong contrast to the remainder of the belt. In narrow areas bordering Chattahoochee, Flint, and Ocmulgee rivers the valley sides have been modified by terracing processes.

Paleontologic characters.—As previously explained, the typical marine beds of this formation contain in many layers an abundance of fossil invertebrate remains, and scattered fragmentary remains of vertebrates.

The formation in the Chattahoochee region is divisible on the basis of the ranges of the contained species of *Exogyra* into two parts. The lower, embracing approximately the lower one-third to one-half of the terrane, is characterized by the presence of *Exogyra ponderosa* Roemer; the upper, embracing the remainder of the formation is characterized by the presence of *Exogyra costata* Say. The former is given the name *Exogyra ponderosa* zone, and to the latter *Exogyra costata* zone.

Since the species *Exogyra ponderosa* occurs also in the underlying Tombigbee sand member of the Eutaw formation the *Exogyra ponderosa* zone includes this member also.

The formation contains a large number of invertebrate species which range from the base, or even below the base of the terrane, to its top; but there are in addition numerous species with restricted ranges, some confined above and some below the horizon separating the two zones.

DETAILED SECTIONS. (PART OF FORMATION INCLUDED WITHIN THE ZONE OF *EXOGYRA PONDEROSA*.)

Chattahoochee River (typical marine beds).—The Ripley formation is exposed on Chattahoochee River in the upper part of the section at Blufftown, 31¼ miles below Columbus, Ga., in Stewart County, Ga., and in bluffs from Florence, 42 miles below Columbus, to a point near Othos Landing, Ala., not exactly determined, about 15 miles below Eufaula, a total distance by the river of about 44 miles. (For the location of the exposures described, see sketch map of the river, figure 6, p. 79.)

The details of the exposure at Blufftown have been described in a section on page 134 of this report. The upper 100 feet of the section is believed to represent the Cusseta sand member of the formation. The next 50 feet, consisting of gray, calcareous, marine sand, with some fossils, is the upper part of the "Blufftown marl" of Veatch, and constitutes the basal portion of the Ripley formation of this report. The following fossils were obtained near the top of this 50-foot division: *Ostrea plumosa* Morton, *Exogyra sp.* (young individual with costæ), *Anomia* sp. nov. (same as sp. nov. from Snow Hill, N. C.)

This gray sand is similar physically to the materials lower down in the section, but the latter contain some fossils which in the light of our present knowledge of their range do not occur at horizons higher than the Tombigbee sand or the extreme base of the Selma chalk.

Below Blufftown to a point two miles below Omaha the river bluffs reveal the beds of the Tombigbee sand member only. From here to Florence there are no exposures, but at the latter place the following section appears:

Section at Florence, Chattahoochee River, left bank, 42 miles below Columbus.

	Feet.
Pleistocene (terrace deposit)	
3. Yellowish sandy clay and sand with gravel band at base	12 to 15
(Unconformity.)	
Upper Cretaceous	
Ripley formation (*Exogyra ponderosa* zone).	

2. Gray to greenish gray, marine sands and clays, more or less glauconitic, micaceous, and calcareous in the different layers. Several rows of calcareous concretions occur near the base. Fossiliferous in lower five or six feet. Shells very soft	20 to 25
1. Laminated sands and clays with lenses of gray, yellow, and brown sands and seams of lignite	10

The bluff at this place is about one-half mile long, and in this distance the bedding plains are seen to dip gently southward. Of the fossils collected here the following were identified.

Chattahoochee River, bluff at Florence, Stewart County, Ga. L. W. Stephenson, collector.

	Locality Number.	
	5395	6404
Vermes:		
Hamulus onyx Morton	x	x
Mollusca:		
Nucula percrassa Conrad	x	
Leda longifrons Conrad ?	x	
Trigonoarca sp.	x	
Arca ?		x
Barbatia (Polynema) lintea Conrad	x	
Barbatia sp.	x	
Ostrea sp.	x	
Ostrea sp. nov. (same as large species at Woolridge Landing)	x	
Exogyra ponderosa var. erraticostata Stephenson	x	x
Trigonia sp. nov. (same as at Snow Hill, N. C.)	x	
Anomia argentaria Morton	x	
Crassatellites sp. nov. (cf. C. pteropsis Conrad)	x	
Cardium eufaulense Conrad	x	
Cyprimeria depressa Conrad	x	x
Aphrodina regia Conrad	x	
Cyclothyris alta Conrad	x	
Cymbophora lintea Conrad	x	
Corbula carolinensis Conrad	x	
Undetermined pelecypods	x	
Vertebrata:		
Crocodilian teeth	x	
Lamna sp.	x	

Two miles below Florence, 44 miles below Columbus, right bank, there is exposed at the foot of a bluff, 25 or 30 feet of dark gray, micaceous, marine clay. A layer of lime concretions occurs about 12 or 15 feet above the base. Fossils, mostly fragile and in a fragmentary condition, occur near zero water level. The horizon is probably about the same as that at Florence.

About 46 miles below Columbus there appears at the base of a bluff 10 or 12 feet of dark gray, compact, marine clay with several layers of slightly indurated light gray sand, each about six inches in thickness. Fragmentary shells occur near water level.

In the vicinity of Woolridge Landing, 46½ miles below Columbus, 13½ miles above Eufaula, Ala., there are several interesting exposures. A short distance above the landing on the opposite side of the river, left bank, the bluff presents the following section:

Section opposite Woolridge Landing, Chattahoochee River.

	Feet.
Pleistocene (first Pleistocene terrace.)	
5. Not well exposed, but mostly yellow sand	15
(Unconformity)	
Upper Cretaceous	
Ripley formation (*Exogyra ponderosa* zone).	
4. Greenish gray, very glauconitic sand, with some indurated layers	10
3. Yellow, laminated, loose sand, and dark drab clay. A layer of decayed shells, among them some large oysters, occurs along the top	15
2. Dark gray shell marl with gray sand matrix. The most conspicuous fossil, a large undescribed species of oyster. Other fossils are: *Trigonia, Cyprimeria densata* (Conrad) sharks teeth (numerous), crocodilian teeth, bones, etc . . .	3
1. Dark gray, argillaceous, micaceous, marine sand, with dark clay streaks	3

Just below Woolridge Landing, right bank, the bluff reveals strata as described in the following section:

Section below Woolridge Landing, right bank, Chattahoochee River.

	Feet.
Pleistocene (second terrace).	
5. Pebbly sand, not well exposed . . . . . . about .	25
Concealed by talus, but probably Cretaceous .	15
Upper Cretaceous.	
Ripley formation. (*Exogyra ponderosa* zone.)	
4. Dark gray, compact, argillaceous, finely micaceous, calcareous, glauconitic sand. One small specimen of *Exogyra* sp. with costae obtained near base	30
3. Yellow, rather loose, sandy shell marl with some dark drab clay laminae. Contains soft shells, including *Exogyra, Anomia, Cardium, Trigonia,* a large undescribed oyster, etc. Also sharks teeth, crocodilian teeth and bones	20
2. Shell marl with gray sand matrix. Shells very soft. About three feet above base a discontinuous layer of large massive oysters, some specimens of which have a measured length of 17.5 inches	6
1. Dark gray, micaceous, argillaceous, marine sand .	5

From the marl, layer No. 2, in the preceding section the following forms were identified:

Chattahoochee River, Woolridge Landing, 46½ miles below Columbus, 13½ miles above Eufaula, in Barbour County, Ala. L. W. Stephenson, collector.

	Locality Numbers	
	5376	6402
Vermes:		
Serpula sp.	x	x
Hamulus ?	x	
Mollusca:		
Nucula percrassa Conrad	x	x
Cucullaea carolinensis (Gabb)	x	
Trigonoarca sp. nov. (cf. with sp. nov. from Kerrs Cove, Black River, N. C.)		x
Breviarca saffordi (Gabb) ?	x	x
Nemodon brevifrons Conrad		x
Arca sp. (cf. A. uniopsis Conrad)		x
Glycymeris sp. (cf. G. congesta (Conrad))		x
Glycymeris sp.		x
Inoceramus sp.	x	
Ostrea tecticosta Gabb		x
Ostrea plumosa Morton		x
Ostrea sp. nov. (very large)	x	x
Exogyra ponderosa var. erraticostata Stephenson	x	
Exogyra sp. (medium sized individual with costae)		x
Trigonia sp. nov. (same as sp. nov. from Snow Hill, N. C.)		x
Pecten burlingtonensis Gabb ?	x	
Pecten sp. ?		x
Plicatula sp.	x	
Anomia lintea Conrad		x
Veniella conradi (Morton)		x
Crassatellites sp. nov.	x	x
Crassatellites sp. (cf. C. carolinensis Conrad)		x
Lucina glebula Conrad	x	
Cardium eufaulense Conrad		x
Isocardia cliffwoodensis Weller ?		x
Cyprimeria depressa Conrad	x	x
Aphrodina regia Conrad	x	
Cyclothyris alta Conrad		x
Legumen planulatum (Conrad)		x
Baroda carolinensis Conrad		x
Cymbophora lintea (Conrad)		x
Corbula carolinensis Conrad	x	x
Gyrodes crenata Conrad	x	
Pugnellus densatus Conrad		x
Undetermined gastropods	x	
Vertebrata:		
Lamna texana Roemer	x?	x
Corax falcatus Agassiz	x?	x
Otodus sp.	x?	x
Ischyrhiza mira Leidy (identified by J. W. Gidley)	x	
Thecachampsa rugosa Emmons (identified by C. W. Gilmore)	x	
Polydectes biturgidus Cope (identified by C. W. Gilmore	x	

At "Roanoke Island," a short distance below Woolridge Landing, Capt. J. W. Singleton, Superintendent, U. S. Engineers, obtained from dredged materials the vertebrate remains listed below. The island referred to no longer exists, having been destroyed by river currents.

Chattahoochee River, between Upper and Lower Roods Bend, and just above mouth of Soapstone Creek. Capt. J. W. Singleton, collector. Identified by C. W. Gilmore.

Various fragments of the turtle, *Taphrosphys* (?)
Fragment of dinosaur limb bone
Vertebra of mosasauroid reptile
Tooth of large crocodilian, probably *Polydectes*
Coprolites

One mile below Woolridge Landing at Lower Roods Bend, the following section is well exposed:

Section at Lower Roods Bend, 47 1/2 miles below Columbus, 12 1/2 miles above Eufaula, left bank.

	Feet.
Pleistocene (terrace deposit).	
3. Unconsolidated, yellowish sand, loamy in upper part and with a band of pebbles and cobbles along the base	25
(Unconformity)	
Upper Cretaceous.	
Ripley formation. (*Exogyra ponderosa* zone.)	
2. Dark gray, massive, marine sand. One specimen full of soft shells. Same as marl, layer No. 3 of *Gryphaea vesicularis* Lamarck obtained . .	20
1. Dark gray, micaceous, argillaceous, sandy marl full of soft shells. Same as marl, layer No. 2 at Woolridge Landing section	10

From the marl at the base of the preceding section, layer No. 1, the following species were recognized:

Locality No. 6401.—Chattahoochee River, left bank, Roods Lower Bend, just below the mouth of Soapstone Creek, 12½ miles above Eufaula, Stewart County, Ga. L. W. Stephenson, collector.

Molluca:
Nucula percrassa Conrad
Leda sp.
Trigonoarca sp. nov. (large)
Glycymeris sp.
Ostrea plumosa Morton
Ostrea sp. nov. (large)
Trigonia sp. nov. (same as sp. nov. from Snow Hill, N. C.)
Pecten sp. nov. (same as species from Snow Hill N. C.)
Anomia argentaria Morton
Crassatellites pteropsis Conrad?
Cardium eufaulense Conrad

Aphrodina regia Conrad
Cyclothyris alta Conrad
Leptosolen biplicata Conrad
Corbula carolinensis Conrad

Vertebrata:
Lamna texana Roemer
Corax falcatus Agassiz
Otodus ?

About three-quarters of a mile below Lower Roods Bend, the top of the marl bed just described is seen to pass finally beneath water level.

Along the outside of the broad bend on the Georgia side of the river between 48 and 49 miles below Columbus, a bluff presents a nearly vertical wall, 40 or 50 feet in height, of dark green, compact, argillaceous, marine sand. Although no fossils were obtained from them, these beds are tentatively regarded as forming the upper part of the *Exogyra ponderosa* zone of the Ripley formation. The top of this zone is believed to pass beneath water level between this bend and the mouth of Cowikee Creek, the materials exposed on this creek, a short distance above the mouth, being regarded as forming the base of the overlying *Exogyra costata* zone.

Northeast of Chattahoochee River (typical marine beds).—The upper part of the section near Jamestown postoffice in Chattahoochee County, 18 miles south of Columbus, Ga. (see section on p. 138 of this report), including layers Nos. 6 to 12 inclusive, is probably referable to the lower part of the Ripley formation. In stratigraphic position these beds are believed to correspond approximately to layer No. 3 of the section at Blufftown on Chattahoochee River (see p. 134 of this report.) This is the farthest point to the northeastward that basal marine beds of the formation have been traced in Georgia. Beyond this point the basal beds appear to merge rapidly into materials of the Cusseta sand type.

Marine beds overlying the Cusseta sand member, and probably occupying positions near the top of the zone of *Exogyra ponderosa,* have been examined at several places northeast of the river as follows:

In a cut of the Seaboard Air Line Railway at Manta (Hichitee P. O.) in Chattahoochee County, weathered, marine materials make up the upper seven feet of the beds exposed and similar materials are poorly exposed on the hill-slope south of the cut, the whole totaling a thickness of about 27 feet. Although no fossils were found in these materials they are thought to belong to the upper part of the zone in question (see section, p. 162.)

Four miles northeast of Buena Vista on the road leading to Tazewell, where it ascends the southward-facing slope of Richland Creek

A. EXPOSURE IN GULLY IN BUENA VISTA-TAZEWELL ROAD, SIX MILES NORTHEAST OF BUENA VISTA, MARION COUNTY, GA., SHOWING LEAF-BEARING CLAY LENS IN CUSSETA SAND MEMBER OF THE RIPLEY FORMATION.

B. "SAND STREAM," ONE MILE NORTH OF TAZEWELL, MARION COUNTY, GA., THE SAND HAS BEEN TRANSPORTED BY TORRENTS FROM GULLIES IN THE CUSSETA SAND MEMBER

Valley, there is in the road ditch near the base of the hill an exposure of 12 or 15 feet of dark gray, fine, argillaceous, marine sand bearing fossil casts. On the basis of the contained fossils this horizon is correlated approximately with the marl beds exposed at the bases of the bluffs on Roods Bend, Chattahoochee River (see pp. 135, 136 of this report.) The following forms were recognized:

Locality No. 5381.—Buena Vista-Tazewell road, about four miles northeast of Buena Vista, Ga., on southward-facing slope of Richland Creek Valley. (All casts.) L. W. Stephenson, collector.

Vermes:
- Serpula sp.

Mollusca:
- Exogyra sp. (cast of young with costae)
- Ostrea sp. (large cast probably same as sp. nov. from Woolridge Landing.)
- Pecten quinquenarius Conrad
- Veniella lineata (Shumard) ?
- Crassatellites sp. (same as sp. nov. from Woolridge Landing, Chattahoochee River.)
- Cyprimeria densata Conrad
- Cyprimeria depressa Conrad
- Cyclothyris ?
- Aphrodina sp.

A section on the Buena Vista-Tazewell road six miles northeast of Buena Vista has already been given on page 139 of this report. The upper 70 feet of the section, consisting of weathered, brownish, marine sand, is believed to fall within the upper part of the zone of *Exogyra ponderosa*. This sand rests upon the coarse, unconsolidated sands of the Cusseta sand member of the Ripley formation. The contact separating the two kinds of materials is somewhat obscured by weathering process and by surface creep, but the relation appears to be that of conformity.

Region between Chattahoochee and Ocmulgee rivers (Cusseta sand member).—From Chattahoochee River northeastward in Georgia, the basal portion of the Ripley formation loses its deeper marine character, being replaced by unconsolidated, coarser, more irregularly bedded sands and clays of shallow marine or estuarine origin. These near-shore deposits have been designated by Veatch[1] the Cusseta sand, from Cusseta, Chattahoochee County, in the vicinity of which they are typically developed.

The materials referred to this member first make their appearance in the high bluff at Blufftown on Chattahoochee River, a section of which is given on page 134 of this report. The upper 100 feet of this section (layer No. 4) is thus referred.

[1]Clay Report: Geol. Survey of Ga., Bull. No. 18, 1909, p. 88.

Exposures of the beds between Cusseta and Manta, a distance of five and one-half miles, in what must be considered the type region, are described below:

A shallow cut of the Seaboard Air Line Railway, in front of the court house at Cusseta, reveals five feet of loose, gray, sharp, rather coarse sand, grading down into compact, reddish sand of the same character, the latter about five feet in thickness. The gray sand is believed to have been derived from the underlying red sand by leaching.

A number of cuts 10 to 15 feet in depth, eastward from Cusseta for a distance of two and three-quarter miles, exhibits sections essentially the same as the preceding, the gray surface sands varying in depth from four to eight feet.

Three miles east of Cusseta, at milepost 22 (from Columbus), a 12-foot cut reveals reddish, mottled, coarse, ferruginous, argillaceous sand reaching a maximum thickness of 10 feet, overlying conformably undulating laminated drab clay and red ferruginous sand beds. The undulations in the stratification lines show differences of level of seven or eight feet in a horizontal distance of 40 or 50 feet. (See plate XIII, B.)

Four miles east of Cusseta the railroad crosses a gully which runs from south to north, at the head of which the following succession of beds is exposed:

Section in gully four miles east of Cusseta, Ga., near Seaboard Air Line Railway track.

	Feet.
Upper Cretaceous.	
Ripley formation (Cusseta sand member).	
5. Loose, gray, coarse sand	4
4. Ferruginous, coarse, massive sand weathered to a rather even, pinkish red color	15
3. Laminated, drab clay and red, ferruginous sand	3
2. Drab, stratified clay with streaks of yellow. This is a lens and is replaced horizontally by sand	·4
1. White, yellow, and red, fine to medium-grained, slightly micaceous, crossbedded sand, with scattered drab clay laminae	14

Immediately west of the station at Manta (Hichitee P. O.) the following section is exposed in a cut:

Section in cut of Seaboard Air Line Railway at Manta Station (Hichitee P. O.), five and one-half miles east of Cusseta, Ga.

	Feet.
Upper Cretaceous.	
Ripley formation (*Exogyra ponderosa* zone).	
(Typical marine sand.)	
5. Weathered, coarse, red, ferruginous, compact, massive sand.	7
(Cusseta sand member.)	

4.	Laminated, drab clay, and red and gray, micaceous sand . .	5
3.	Gray, medium to coarse, micaceous sand with scattered drab clay balls, the whole mottled with purple	7
2.	Laminated, drab clay, streaked with yellow	4
1.	Medium to very coarse, gray sand, tinted with pink, and locally indurated to a purple ferruginous sandstone	11

The relation of the Cusseta sand member to the superincumbent typical marine beds as revealed in the cut, is one of conformity, sedimentation having been continuous from the one to the other.

In Marion County the Cusseta sand member outcrops in a belt extending in a northeast-southwest direction, having a width of perhaps four miles on the western border, and eight or ten miles on the eastern border of the county. The materials seem to consist almost entirely of unconsolidated sands with subordinate clay lenses.

The following section was made along the road leading from Buena Vista to Tazewell, about six miles northeast of the former place:

Section along Buena Vista-Tazewell road, six miles northeast of Buena Vista.

Upper Cretaceous.	
Ripley formation (*Exogyra ponderosa* zone.)	
(Typical marine beds.)	Feet.
2. Brownish marine sand (weathered), about	70
(Cusseta sand member.)	
1. Coarse, light-colored, crossbedded, arkosic sand, locally ferruginous with iron concretions, with white to black clay lenses. The clay lenses are local in character giving place in a short distance to sand. The maximum thickness of clay observed is 12 feet. In a lens of black clay near the base fossil leaves were collected	50

The leaf-bearing lens of black clay, described in the preceding section, has a thickness of four or five feet (see plate XIV, A.). The leaf remains are scattered somewhat sparingly through the clay. E. W. Berry, to whom the plants were submitted, recognized the following species: (See also Bull. Torrey Botan. Club No. 37, 1910, p. 505.)

Andromeda novae-caesareae Hollick
Araucaria bladenensis Berry
Doryanthophyllum cretaceum Berry
Eucalyptus angusta Velen.
Ficus sp. nov.
Manihotoides sp. nov. (same as at McBride Ford)
Monocotyledon, gen. et sp. nov. (common to the Black Creek and Tuscaloosa formations)

In the vicinity of Tazewell the surface materials consist principally of coarse, loose sands apparently derived by weathering from

the Cusseta sand member. These surface sands are easily transported, and at times of heavy precipitation have been washed down into the small headwater branches forming so-called "sand-streams." (See plate XIV, B.)

The following is the log of a well owned by B. F. Duke, eight miles northeast of Buena Vista, Ga. The owner is authority for the lithology:

Log of well on property of B. F. Duke, eight miles northeast of Buena Vista, Ga.

Upper Cretaceous.		
Ripley formation (Cusseta sand member).		Feet.
4.	Very hard clay	0 to 12
3.	Yellow sand	12 " 92
2.	"Chalk" (clay)	92 " 104
1.	Yellow sand, water-bearing	104 " 140

The Cusseta sand member is present in a small area in the northern part of Schley County, but the available data are meager. The same division furnishes the surface materials over about the southern two-fifths of Taylor County. Concerning the character of the materials Veatch says: (Clay report, p. 224.)

> The sand in the southern part of the county contains noticeably more iron and the clay beds are thinner and less pure. A characteristic feature is thin crusts of layers, a few inches thick, and large, hollow nodules of siliceous limonite; the latter are so abundant in some localities that they may be of some value in the future as a source of iron.

The logs of three wells in this county which are believed to penetrate strata of this division are given below:

Log of well owned by J. L. Whitley, one and one-half miles north of Mauk, Ga. (Mouth of well level with the track of the Atlanta, Birmingham & Atlantic Railroad.) Authority for lithology, the owner.

Ripley formation (Cusseta sand member).		Feet.
7.	Sand	0 to 8
6.	Clay	8 " 13
5.	Sand	13 " 38
4.	"Chalk" (clay)	38 " 42
3.	Sand	42 " 60
Eutaw formation ?		
2.	Black marly "chalk" (clay)	60 " 73
1.	"Chalk" (clay) and sand, water-bearing in basal two feet	73 " 125

Log of well owned by George Ruffin, one and one-half miles east of Mauk, Ga. Authority for lithology, J. A. Steed, Mauk, Ga.

Upper Cretaceous.	
Ripley formation (Cusseta sand member).	Feet.
5. Clay	?
4. Sand	?
3. "Chalk" (clay) and sand	?
2. Coarse sand	?
1. White pebble rock	?
Total	90

Log of well three-eighths of a mile north of Southland, Ga., owned by W. G. Hill. Authority for lithology, owner. (Mouth of well about 60 feet above track at station.)

Upper Cretaceous.	
Ripley formation (Cusseta sand member).	Feet.
3. Sand	0 to 3
2. "Chalk" (white clay) and clay	3 to 12
1. Fine sand of various colors, water-bearing in lower two feet	12 to 75

Strata belonging to the Cusseta sand member underlie the northern part of Macon County in an area embracing about one-third of the county. In a gully in the high scarp facing Flint River, five or six miles west of Marshallville, Ga., over 100 feet of materials are exposed, consisting of coarse to fine, more or less arkosic, crossbedded sand with occasional lenses of light drab clay. The sand contains small clay balls in places. About half way to the top of the section an indurated ironstone forms a projecting ledge, and just below this is a layer of large, mechanically included, clay balls. The sands above the indurated layer are more argillaceous than those below it. This whole section is believed referable to the Cusseta member.

At Underwood Ferry, Flint River, one and one-half miles below the locality described, weathered marine sand, poorly exposed about 10 feet above water level, contains soft casts of *Venericardia planicosta*. It is therefore of Eocene age. If the materials in the gully just described, one and one-half miles north of this place, are of Cretaceous age, as interpreted, there must be a profound unconformity separating the Cretaceous and Eocene deposits, for the difference in level between the Underwood Ferry exposure and the top of the section in the gully must be fully 150 feet. The fossil-bearing sand at Underwood Ferry, however, is poorly exposed, and there is a possibility of its having slipped down from a higher level.

There are exposures of coarse sands and light colored clays at a water mill about three miles south of Reynolds, Ga., which are believed referable to this division.

About six miles north of Marshallville the following section is exposed in gullies on the west side of the road:

Section about six miles north of Marshallville, on road farthest west leading from Marshallville to Everetts Station.

	Feet.
Upper Cretaceous.	
Ripley formation (Cusseta sand member).	
4. Deep red ferruginous sand	10 to 15
3. Coarse to fine, crossbedded, loose sand with thin iron crusts, occasional thin clay laminae, and in places scattered, small clay balls	30
2. Bed of purple, massive clay forming a fairly persistent layer	5 to 6
1. Loose, coarse, crossbedded sand with thin clay laminae which are especially numerous in the upper portion	15

One-half mile farther north on the same road a gully on the west side, furnishes the following section:

Section on road farthest west leading from Marshallville to Everetts Station, six and one-half miles north of Marshallville.

	Feet.
Upper Cretaceous.	
Ripley formation (Cusseta sand member).	
2. Coarse, red, ferruginous sand, with scattered, small quartz pebbles. Appears to grade down through a mottled band into the underlying material	15
1. Fine, yellow, massive, micaceous, somewhat argillaceous, fairly compact sand	20

The red sands in the upper parts of the two preceding sections resemble closely the ferruginous sand formation of supposed Eocene age exposed in cuts in the vicinity of Fort Valley and at Zenith, and they may represent that formation, although no evidence of an unconformity separating them from the underlying materials was observed at these localities.

The following statements concerning the occurrence of Cretaceous strata in this county are quoted from Veatch's clay report:

"In the northern half of Macon County, there is a belt of Upper Cretaceous sands in which pockets and beds of white clay have been found. At no place where these have been examined, do they approach in purity and thickness the clay beds of the Tuscaloosa [Lower Cretaceous, but not Tuscaloosa] east of the Ocmulgee River. * * *

"Some white-stained clay was noted on the west side of Flint River, north of Oglethorpe. A clay bed is exposed in the cut of the Atlanta, Birmingham & Atlantic Railroad, near Maverick, and a bed may be seen in the public road about three-quarters of a mile west of Maverick, adjoining the property of J. M. Childs. The bed at the latter locality is 8 feet thick; it is white with purplish and red stains, which seem to penetrate the mass of the clay, and in places is quite sandy. * * *

"There are a large number of exposures of clay in the red sands west and northwest of this locality; some of the exposures noted showing a thickness of 15 feet or more, but all were splotched with iron oxide stains."

A strip of country, several miles wide, along the southeastern side of Crawford County, is believed to fall within the Cusseta sand belt. As interpreted, the member here rests with unconformable relations upon Lower Cretaceous beds. This conclusion is based upon data obtained from observations in cuts of the Southern Railway, just north of Zenith, Ga. Over a part of the area, the division is overlain unconformably by a red, ferruginous sand formation, the age of which has not been determined, but which is probably a northward overlap of one of the Eocene formations.

The graphic section given in margin shows the relations between the formations exposed in the cuts near Zenith.

Explanation of Figure.

3. Eocene?—Coarse, deep red, ferruginous sand, becoming coarser and pebbly in lower two feet; the pebbles are of quartz and reach a maximum diameter of two inches. Along the base occurs a line of irregular, partially silicified white clay fragments reaching a maximum diameter of one foot. The clay fragments are numerous in places, and elsewhere are scattered. (See plate XVII, A.)

(Unconformity.)

2. Upper Cretaceous.—Ripley formation (Cusseta sand member). An irregularly bedded formation consisting principally of light gray or yellow, fine stratified sand with thin laminae of drab clay and very thin iron crusts; but at intervals there occur lenses of white or yellow sand in places ferruginous; and in places this argillaceous content increases forming thinly laminated clay beds with fine sand partings; one of these clay beds, *a* in the section, becomes very carbonaceous, being filled with scattered particles and seams of comminuted plant fragments.

(Unconformity.)

1. Lower Cretaceous.—A formation consisting principally of coarse, gray sands with important clay lenses. The cuts toward the northern end of the section reveal immediately beneath the contact a bed of massive clay, light in color, but blotched with purple and pink tints.

Logs of two wells southeast of Zenith which penetrate the Cusseta sand have been obtained. The owners are authority for the lithology.

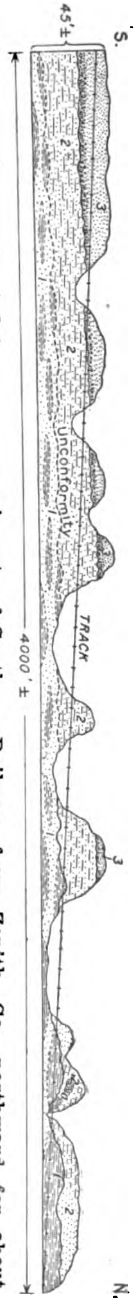


Fig. 10.—Section constructed from exposures in cuts of Southern Railway, from Zenith, Ga., northward for about three-quarters of a mile.

Log of well on property of J. W. George, one-half mile south of Leepope, Ga.

	Feet.
Eocene ?	
8. Soil	0 to 2
7. Stiff red clay	2 to 22
Upper Cretaceous	
Ripley formation (Cusseta sand member).	
6. "Chalk" (clay) and gravel	22 to 32
5. Coarse sand and gravel, some water	32 to 35
4. Blue "chalk" (clay)	35 to 47
3. Coarse brown sand	47 to 65
2. White and blue sticky "chalk" (clay)	65 to 68
1. Fine sand and gravel, water-bearing	68 to 72

Log of well on property of Isaac Miller, of Fort Valley, Ga., four and one-half miles northwest of Fort Valley, in Crawford County, Ga.

	Feet.
Eocene ?	
5. Clay	0 to 25
Upper Cretaceous.	
Ripley formation (Cusseta sand member).	
4. Yellow sand	25 to 75
3. White sand with some purple sand	75 to 90
2. Dark gravel and rocks (pebbles ?)	90 to 100
Lower Cretaceous ?	
1. "Chalk" (clay)	100 to 103

The so-called "chalk" in the above section may correspond to the clay at the base of the section in the railway cuts north of Zenith, Ga. It is therefore tentatively regarded as Lower Cretaceous.

Outcrops of the Cusseta sand member occur in the northern part of Houston County; but over most of the area the beds are concealed by a comparatively thin, ferruginous sand formation, probably of Eocene age, and appear only in stream valleys where erosion has uncovered them, or in artificial cuttings. A good exposure occurs in a cut of the Central of Georgia Railroad, one and one-half miles northeast of Fort Valley. The graphic representation of this occurrence given below is introduced for the purpose of comparison with a similar representation of the occurrences near Zenith, Ga. (See p. 143 of this report.)

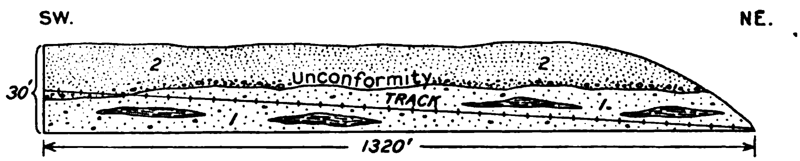


Fig. 11.—Section in cut of Central of Georgia Railway, one and one-half miles nortnwest of Fort Va.ley, Ga.

Explanation of figure.

2. Eocene?—Deep red, massive, coarse, highly ferruginous, more or less argillaceous sand, much coarser in lower 1 to 2 feet, with scattered quartz pebbles reaching several inches in diameter. Along the immediate base are occasional partially silicified clay balls reaching a maximum diameter of 8 inches, reworked from the underlying beds, and scattered fragments of reworked iron crust.

   (Unconformity, obscured in places by weathering.)

1. Upper Cretaceous—Ripley formation (Cusseta sand member). Light gray, coarse, argillaceous sand with lenses of coarse sandy, light colored clay, all more or less streaked with yellow and pink. The sand in places contains small pebbles up to one-half inch in diameter.

Layer No. 2 of this section is believed to correspond to layer No. 3 in the section at Zenith—the red, ferruginous sand of probable Eocene age being the surface formation over the level stretch of country extending from Fort Valley to Zenith. Layer No. 1 of this section corresponds to layer No. 2 of the Zenith section.

About 100 yards northeast of the cut just described, a cut, the top of which is at a slightly lower level, reveals about 20 feet of light-colored Cretaceous sands and clays, the lower five feet of which has a laminated appearance.

At two and one-half miles northeast of Fort Valley on the same railroad, a cut reveals the following:

Section Central of Georgia Railway, two and one-half miles northeast of Fort Valley, Ga.

	Feet.
Eocene ?	
3. Loose, gray, residual sand	2
2. Mottled, red, highly ferruginous, coarse sand, fragments of iron crusts in places along base .	5
Upper Cretaceous.	
Ripley formation (Cusseta sand member).	
1. Light gray, coarse, crossbedded, argillaceous sand and sandy clay	18

Section in cut six miles northeast of Fort Valley, Ga.

	Feet.
Eocene ?	
2. Coarse, red, ferruginous sand, with a fairly persistent line of pebbles along the base. Fragments of fine, yellow sandstone with a maximum length of 8 inches were observed at one place near the base	8
Upper Cretaceous.	
Ripley formation (Cusseta sand member).	
1. Coarse, yellow and red, somewhat ferruginous sand, with thin lenses and layers of drab, sandy clay, and in places lines of small white clay balls	8

One-half mile northeast of the station at Byron a section is revealed in a cut, as described below:

Section in cut one-half mile northeast of the station at Byron, Ga.

	Feet.	In.
Eocene ?		
6. Loose, gray, residual sand		1
5. Weathered, yellow, ferruginous sand, with small, round, iron concretions. Grades down into next layer		3
4. Weathered, mottled yellow and red, massive, rather coarse, argillaceous, ferruginous sand .		6
3. Sharply defined layer of mottled drab and yellowish, finely arenaceous clay	2	6
2. Pinkish tinted, massive, loose sand, fine at top, becoming coarser to very coarse at base. In lower 1 to 2 feet contains numerous, small, angular, quartz pebbles reaching one inch in diameter, and scattered, angular white clay masses reaching several inches in diameter		6
(Unconformity, somewhat obscured in places by weathering.)		
Upper Cretaceous.		
Ripley formation (Cusseta sand member).		
1. Coarse, white or light gray, crossbedded, arkosic sand, with subordinate white clay lenses . . .		12

One-half mile northeast of the preceding, a cut reveals six feet of weathered, mottled, red ferruginous sand, with pebbles and clay balls along the base, resting unconformably upon coarse, crossbedded sand. The former corresponds to layer No. 2 and the latter to layer No. 1 in the preceding section.

The red, ferruginous materials overlying the Cusseta sand at all the localities between Fort Valley and this point described on preceding pages, are believed to be of Eocene age, as they are separated from the Cretaceous by an unconformity. The unconformable relation of the two is not everywhere directly apparent, due to the weathering effects resulting from the close proximity of the contact to the surface.

One and one-half miles northeast of Byron a cut reveals materials as graphically represented below:

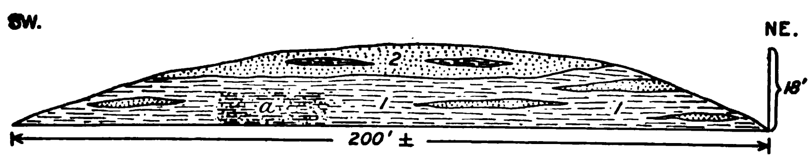


Fig. 12.—Section in cut of Central of Georgia Railway, one and one-half miles northeast of Byron, Ga.

Explanation of Figure.

Upper Cretaceous.
Ripley formation (Cusseta sand member).
2. Light gray, coarse, rather loose, crossbedded sand streaked with yellow, with subordinate clay lenses.

1. For the most part light to drab clay with subordinate sand layers and lenses, in part laminated and in part massive. At one place, *a* in the section, there is about 6 feet of dark drab to chocolate carbonaceous clay filled with comminuted plant particles, which grades laterally into the lighter clays. The lower part of the dark clay is laminated, with fine sand partings; the upper part is more massive and in this were found a few determinable plant remains.

The plants from layer No. 2 were submitted to E. W. Berry, who furnished the following list: (See also Bull. Torrey Botan. Club No. 37, 1910, p. 505.)

Araucaria jeffreyi Berry
Cunninghamites elegans (Corda) Endl.
Dryopteris sp. nov.

At mile-post 15 on the Central of Georgia Railway, two miles northeast of Byron, a cut reveals about 50 feet of Cusseta materials consisting of light gray, coarse to very coarse, arkosic, incoherent sand with subordinate lenses of light drab to white, massive clay reaching several feet in thickness. Veatch has described the clay lenses in these sands from the economic standpoint in his clay report, pp. 213-215.

A well owned by J. W. Epting, one and one-quarter miles southwest of Powersville, probably penetrates the strata of this formation. The log is given below. The owner is authority for the lithology.

Log of well one and one-quarter miles southwest of Powersville, Ga.

	Feet.
Eocene ?	
5. Clay . . . . about	0 to 30
Upper Cretaceous.	
Ripley formation (Cusseta sand member).	
4. "Chalky" (clayey) strata gradually becoming sandy, (some water) . . . . about	30 to 60
3. Clay . . . . about	60 to 85
2. Sandy "chalky" (clayey) strata, yellowish, about	85 to 108
1. Coarse, white sand, water-bearing	108 to 110

A well owned by H. C. Harris at Fort Valley, Ga., the log of which is given below, probably penetrates the entire thickness of this formation:

Log of well at Fort Valley, Ga., furnished by the owner.[1]

	Feet.
8. Red clay	20
7. Sand	20
6. White clay	8
5. Yellow sand	40
4. White clay	10
3. Quicksand with pebbles	400
2. Hard rock . . . . Thickness not given	(?)
1. Quicksand . . . . Thickness not given	(?)
Total	1075

[1]Quoted from Bull. Geol. Survey of Georgia No. 15, 1908, p. 120.

With the exception of the upper 20 feet, which is probably referable to the Eocene, the beds penetrated in the Fort Valley well are all of Cretaceous age. Doubtless the Cusseta sand member of the Ripley formation, which immediately underlies the red Eocene stratum at the surface, was entirely penetrated, and the deeply buried, underlying Lower Cretaceous strata entered to a depth of several hundred feet. Indeed, it seems probable, if the depth reached was as great as given, that the bottom of the well was very near the crystalline basement rocks when the drilling was discontinued.

A well at Byron, described below, is believed to have passed through 15 or 20 feet of Eocene strata in its upper part, below which the beds penetrated probably all belong to the Cusseta sand member.

Log[1] of well at Byron, Ga.

	Feet.	
Sand and "chalk" (kaolin)	0	250
Quicksand and "chalk" (kaolin) in 3-foot layers, water bearing stratum, coarse sand	250	310

It is believed that the Cusseta sand belt extends eastward from Byron through the southern part of Bibb County into the extreme western part of Twiggs County, and somewhere to the west of Bullards passes under the overlying Eocene beds. Little detailed information is available in this region, however, and until such has been obtained the exact limits of the division with respect to the underlying Lower Cretaceous beds and the overlying Upper Cretaceous (Providence sand) and overlapping Eocene beds, must remain indefinite.

The log of one well near Walden, in southern Bibb County, which penetrates the Cusseta sand member, is given below:

Log of well one and one-half miles west of Walden, Ga., owned by W. G. Middlebrooks. The owner is authority for the lithology.

	Feet.	
Upper Cretaceous.		
Ripley formation (Cusseta sand member).		
3. Red clay	0	22
2. White sand and kaolin, about	22	70
1. Clay and sand, water-bearing	70	82

DETAILED SECTIONS (EXOGYRA COSTATA ZONE).

Chattahoochee River (typical marine beds).—In bluffs just below the mouth of Cowikee Creek and in a bluff about 40 feet high on Cowikee Creek, a few hundred yards above its junction with the

[1]Geol. Surv. of Ga., Bull. No. 15, 1908, p. 122.

river, dark gray to almost black, compact, argillaceous, micaceous, marine sand is well exposed. A few scattered fossils were found here, comprising marine or brackish water shells and plants associated in the same layers. The plant remains bear signs of considerable trituration. They were probably floated into the body of water where deposition was taking place, and becoming water-logged sank and mingled with the shells.

The following are the invertebrates recognized from the locality just described:

Cowikee Creek, Barbour County, Ala., near mouth. Collectors, T. W. Stanton and L. W. Stephenson.

	Locality Numbers.	
	T. W. S. 853	L. W. S. 6399
Mollusca:		
Nucula sp. (small)	x	x
Nucula sp.		x
Ostrea plumosa Morton		x
Ostrea subspatulata Forbes? (young individual)		x
Cymella bella Conrad		x
Liopistha sp.		x
Leptosolen sp.	x	

The invertebrates at this locality are closely associated with poorly preserved leaf remains, of which the following were identified by E. W. Berry:

Bauhinia sp. nov.
Platanus sp. nov.
Laurus sp.
Salix sp.
Sapindus sp.
Fern, not determinable.

Opposite the mouth of Burstahatchee Creek, right bank, about five and one-half miles above Eufaula, 15 or 20 feet of dark gray, compact, calcareous sand appears above water level. This horizon is well within the *Exogyra costata* zone. The following fossils were obtained here:

Chattahoochee River, right bank, opposite mouth of Burstahatchee Creek, about five and one-half miles above Eufaula in Barbour County, Ala. T. W. Stanton and L. W. Stephenson, collectors.

	Locality Numbers.	
	T. W. S. 853	L. W. S. 6398
Echinodermata:		
Hemiaster ungula (Morton) (Identified by W. B. Clark)	x	
? Coptostoma mortoni (de Leriol) (Identified by W. B. Clark	x	
Mollusca:		
Inoceramus sp.		x
Ostrea plumosa Morton		x
Ostrea larva Lamarck	x	
Ostrea subspatulata Forbes ? (young ind.)	x	
Ostrea sp.	x	
Gryphaea vesicularis Lamarck		x
Exogyra costata Say		x
Pecten quinquescostatus (Sowerby)	x	x
Anomia argentaria Morton	x	x
Paranomia scabra (Morton)	x	x
Veniella conradi (Morton)		x
Cardium sp.		x
Scala sillimani (Morton)	x	
Turritella trilira Conrad		x
Pyropsis sp.		x
Arthropoda:		
Crab remains	x	

Just below the mouth of Burstahatchee Creek on the Georgia side the river impinges against the base of a hill having a height above zero water level of 240 or 250 feet. Only about the upper 100 feet of the section is clearly exposed. The following is a description of the strata:

Section at Stewarts Hill, Chattahoochee River, five and one-half miles above Eufaula, Ala.

	Feet.	In.
Upper Cretaceous.		
Ripley formation (Layers 8 to 15 inclusive probably represent the transition from the typical marine beds to the Providence sand member.)		
15. Coarse, red and yellow, argillaceous sand, well exposed only in lower 5 feet	10	
14. Layer of ironstone averaging 2 inches	0	2
13. Laminated, fine, varicolored, argillaceous, micaceous sand, becoming more argillaceous to a clay at base	10	
12. Coarse, gray and reddish, argillaceous sand	5	
11. Laminated, varicolored, finely arenaceous, micaceous clay with pockets and small lenses of coarse sand	4	
10. Irregular layer of coarse ironstone	0	1-5
9. Coarse, rather loose, yellow, arkosic sand	9	

8. Irregular layer of ironstone, averaging	0	2
7. Fine, greenish gray, argillaceous, micaceous sand, finely mottled with yellow	22	
6. Finely laminated sand and clay with thin plates of ironstone	3	
5. Fine, gray, micaceous sand, delicately mottled with purple, red and yellow	20	
4. Coarse ironstone	0	6
3. Mottled, fine, gray, micaceous sand	10	
2. Gray, micaceous, sand and dark, laminated, micaceous clay, poorly exposed . . . . about	30	
1. Concealed, except masses of dark gray marine sands and clays at base which are not in place but have slipped down from a higher level . . . . about	125	

Between Stewarts Hill and Eufaula there are numerous bluffs where the river cuts against the edge of the lowest Pleistocene terrace, exposing at their base 30 or 40 feet of Ripley strata which are overlain by 10 to 20 feet of Pleistocene terrace sand and clay. The Cretaceous materials consist principally of gray, more or less calcareous and argillaceous, compact, marine sands, some layers of which are indurated, forming projecting ledges along the faces of the bluffs. In places the argillaceous content increases, forming dark, finely arenaceous clays. The materials are more or less fossiliferous, and although no collections are now available for study it is doubtless entirely feasible to make such collections.

At St. Francis Bend, two and one-half miles above Eufaula, Ala., Capt. J. W. Singleton, Superintendent U. S. Engineers, of Columbus, Ga., collected a fragment of a dermal scute and the symphysical portion of the lower jaw of a *Gavial.* These were received by the National Museum through Prof. S. W. McCallie, State Geologist of Georgia. They were identified by C. W. Gilmore.

At Eufaula there is an excellent exposure of the beds of this division in the river bluff below the wagon bridge. (See plate XV, B.)

Section at Eufaula, Alabama.

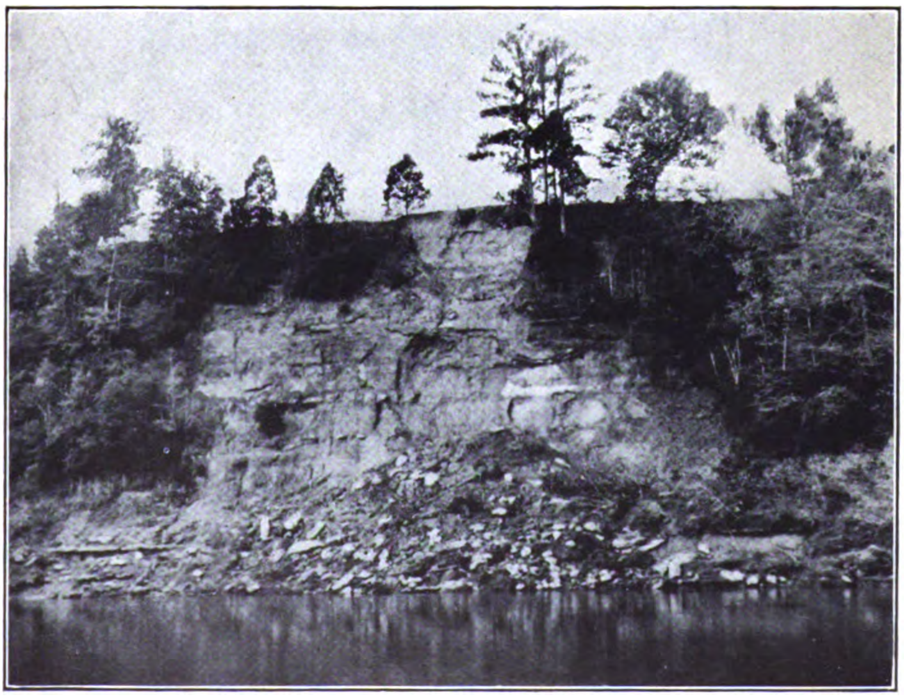
	Feet.
Pleistocene (second terrace deposit above river level).	
2. Yellow and red, argillaceous, more or less pebbly sand	20
(Unconformity).	
Upper Cretaceous.	
Ripley formation. (*Exogyra costata* zone.)	
1. Dark gray to black, more or less calcareous, micaceous and glauconitic sand and clay, extremely micaceous in some layers, with indurated nodular, calcareous layers, 5 to 10 feet apart. Contains fossils	80

This is the type locality for a large number of fossils described by the early investigators of the Cretaceous deposits of this region. The following list has been prepared from the collections of different workers, made since the year 1890.

Eufaula, Ala. Collectors, W. P. Copeland, L. C. Johnson, T. W. Stanton, L. W. Stephenson.

	Locality Numbers					
	L.C.J. 186	W.P.C. 889	T.W.S. 854	L.W.S. 5416	L.W.S. 6400	
Coelenterata:						
Undetermined coral			x			
Echinodermata:						
Hemiaster lacunosus Slocum (Identified by W. B. Clark)			x			
Cassidulus micrococcus Gabb Ident. by W. B. Clark)						x
Vermes:						
Serpula barbata Morton					x	
Hamulus onyx Morton				x		
Mollusca:						
Nucula percrassa Conrad			x			
Nucula distorta Gabb ?			x			
Nucula sp.			x			
Leda pinnaforma Gabb			x	x	x	
Cucullaea vulgaris Morton (var.)			x			
Breviarca cuneata (Gabb)			x			
Nemodon eufaulensis Conrad			x	x	x	
Glycymeris subaustralis (d'Orbigny)			x	x	x	
Gervilliopsis ensiformis Conrad			x		x	
Inoceramus sp.			x	x	x	
Pteria ?			x	x		
Ostrea larva Lamarck	x		x		x	
Ostrea tecticosta Gabb	x		x	x	x	
Ostrea subspatulata Forbes	x		x			
Ostrea plumosa Morton			x			
Ostrea peculiaris conrad			x			
Gryphaea vesiculáris Lamarck	x		x		x	
Exogyra costata Say	x	x	x		x	
Trigonia eufalensis Gabb		x	x	x	x	
Trigonia sp.			x			
Pecten simplicius Conrad			x	x	x	
Pecten argillensis Conrad			x			
Pecten tenuitestus Gabb			x			
Pecten sp.			x			
Lima reticulata Forbes			x		x	
Anomia argentaria Morton	x		x		x	
Anomia sp.			x			
Paranomia scabra (Morton)	x		x		x	
Grenella serica Conrad			x	x	x	
Dreissensia tippana Conrad			x			
Pholadomya occidentalis Morton	x		x	x		
Anatimya anteradiata (Conrad)			x			
Veniella conradi (Morton)			x	x	x	
Vetericardia crenalirata (Conrad)			x	x	x	
Crassatellites eufalensis Gabb			x	x		
Crassatellites pteropsis Conrad			x			
Tenea pinguis Conrad ?			x			
Sphaerella concentrica Conrad			x		x	
Cardium eufaulense Conrad			x			

A. EXPOSURE ON MERCERS MILL CREEK, NEAR GEORGETOWN IN QUITMAN COUNTY, GA., SHOWING FOSSILIFEROUS, MARINE SANDS OF THE RIPLEY FORMATION.



B. BLUFF ON CHATTAHOOCHEE RIVER, AT EUFAULA, ALA., SHOWING 80 FEET OF GRAY, CALCAREOUS, MARINE SANDS AND CLAYS OF THE RIPLEY FORMATION.

	Locality Numbers				
	L.C.J. 186	W.P.C. 389	T.W.S. 854	L.W.S. 5416	L.W.S. 6400
Cardium spillmani Conrad			x		
Cyprimeria depressa Conrad . . .			x		
Cyprimeria alta Conrad			x		
Aphrodina tippana (Conrad) . . .			x	x	
Legumen planulatum (Conrad) .			x		x
Aenona eufalensis Conrad			x		
Linearia sp. (cf. L. carolinensis Con.			x		
Linearia sp.				x	
Leptosolen biplicata Conrad . . .			x	x	x
Cymbophora lintea (Conrad) . . .			x		
Corbula crassiplica Gabb			x		
Corbula (other speecies)			x		
Teredo sp.	x				x
Dentalium ripleyanum Gabb . . .					x
Lunatia obliquata M. & H. . . .			x		
Turritella vertebroides Morton . .				x	
Turritella trilira Conrad				x	x
Pterocerella sp.		x			
Anchura sp.			x		
Pugnellus densatus Conrad			x		
Ringicula pulchella Shumard . . .				x	
Nautilus dekayi Morton			x		
Baculites sp.			x		
Turrilites ?				x	
Arthropoda:					
Bairdro sp. (Ostracoda indentified by R. S. Bassler)				x	
Crab remains	x	x			

Prof. Eugene A. Smith[1] has published the log of a well located at Eufaula which throws light on the character of the materials beneath water level at this place. It is quoted as follows:

Record of Eufaula Oil and Gin Company's well, Eufaula.

	Feet.
Top soil and sand	0 to 30
Marl	30 " 380
Soft sandstone	380 " 381
Cavity with a little water	381 " 389
Marl, water below in very fine sand	389 " 950

More than half the thickness of strata described in this log doubtless belongs to the Ripley formation, but it is probable that several hundred feet of the underlying Eutaw strata were penetrated.

Below Eufaula, typical beds of the formation are exposed in numerous bluffs. The fossils listed below were collected by Dr. T. W. Stanton at a point two miles below the landing at Eufaula.

[1]Geol. Surv. of Alabama. The Underground Water Resources of Alabama, Montgomery, 1907, p. 240-241.

Locality No. 857. Chattahoochee River, between Eufaula and Barbour Creek. T. W. Stanton, collector.

Mollusca:
- Nucula eufalensis Gabb
- Nucula percrassa Conrad
- Nucula cuneifrons Conrad
- Leda pinnaforma Gabb
- Ledo longifrons Conrad
- Cucullaea sp.
- Breviarca cuneata (Gabb)
- Nemodon eufalensis Conrad
- Glycymeris subaustralis (d'Orbigny)
- Glycymeris subaustralis (d'Orbigny) (var. ?)
- Glycymeris sp. ?
- Gervilliopsis ensiformis (Conrad)
- Perna sp.
- Exogyra costata Say
- Gryphaea vesicularis Lamarck (small)
- Trigonia eufalensis Gabb
- Pecten argillensis Conrad
- Pecten simplicius Conrad
- Pecten quinquenarius Conrad
- Lima acutilineata (Conrad)
- Lima reticulata Forbes
- Lima pelagica (Morton)
- Anomia argentaria Morton
- Anomia sp.
- Pulvinites argentea Conrad
- Crenella serica Conrad
- Dreissensia tippana Conrad
- Cuspidaria ventricosa Meek & Hayden
- Liopistha protexta Conrad
- Veniella conradi (Morton)
- Vetericardia crenalirata Conrad
- Crassatellites eufalensis Gabb
- Crassatellites pteropsis Conrad
- Crassatellites sp.
- Cardium kümmeli Weller
- Cardium eufaulense Conrad
- Cyprimeria alta Conrad (var. ?)
- Linearia metastriata Conrad
- Linearia (other species)
- Corbula crassiplica Gabb
- Corbula (several other species)
- Undetermined pelecypods
- Gastrochaena americana Gabb
- Dentalium ripleyanum Gabb
- Dentalium sp.
- Cadulus obnutus (Conrad)
- Lunatia obliquata M. & H.
- Turritella trilira Conrad
- Turritella vertebroides Morton
- Turritella (other species)
- Fusus sp.
- Volutomorpha dumanensis Dall
- Morea cancellaria Conrad
- Undetermined gastropods
- Turrilites alternatus Tuomey

Arthropoda:
- Crab remains

One mile below the mouth of Barbour Creek on the Georgia side of the river, eight or ten feet of gray, marine sand with indurated ledges is exposed. The materials above one of these ledges, six or seven feet above low water, have been washed away over a considerable area by the high waters, forming a shelf. Large numbers of specimens of *Exogyra costata* Say and *Gryphæa* Lamarck, washed from the Cretaceous materials, have accumulated in the shallow basins on this shelf.

Eight miles below Eufaula, near Alexanders Landing, on the Alabama side, materials outcrop as described in the following section:

Section, Chattahoochee River, Alexanders Landing, eight miles below Eufaula, Ala., right bank.

	Feet.
Pleistocene (terrace deposit)	
3. Slope covered with vegetation except a gravel band along base	20 or 30
(Unconformity.)	
Upper Cretaceous.	
Ripley formation. (*Exogyra costata* zone).	

2. Coarsely arenaceous limestone with numerous specimens of Echinodermata. One specimen of *Ostrea subspatulata* Forbes (variety) also obtained	15
1. Dark gray, more or less argillaceous, very micaceous marine sand	15

Prof. Wm. B. Clark, to whom the specimens were submitted, identified the following species of Echinodermata from layer No. 2 of the preceding section:

Cassidulus porrectus Clark
Cassidulus subconicus Clark
Cassidulus subquadratus Conrad

When this locality was visited by Dr. Stanton there was exposed, somewhere near Alexander's Landing, above layer No. 2 of the preceding section, a bed, consisting of unconsolidated marine material from which Dr. Stanton collected the following species:

Locality No. 856.—Chattahoochee River, Alexanders Landing, eight miles below Eufaula, Ala. Collector, T. W. Stanton.

Mollusca:
- Nucula percrassa Conrad
- Nucula distorta Gabb ?
- Nucula sp.
- Leda pinnaforma Gab
- Leda sp. cf. L. marlboroensis Weller
- Cucullaea antrosa Morton
- Breviarca cuneata (Gabb)
- Nemodon eufalensis Conrad
- Glycymeris subaustralis (d'Orbigny)
- Pecten argillensis Conrad
- Pecten simplicius Conrad
- Anomia linifera Conrad
- Anomia sp. nov. (same as "Narrows" of Pataula Creek)
- Dreissensia tippana Conrad
- Pholadomya occidentalis Morton
- Pholadompa sp. nov. (same as at "Narrows" of Pataula Creek)
- Liouistha protexta Conrad
- Crassatellites pteropsis Conrad
- Cyprimeria depressa Conrad
- Linearia ?
- Aenona eufalensis Conrad
- Cymbophora lintea Conrad ?
- Corbula (several species)
- Lunatia obliquata Meek & Heyden
- Gyrodes sp.
- Undetermined pelecypods and gastropods
- Hamites sp. nov. (same as at Prairie Bluff, Ark., etc.)

Arthropoda:
- Crab claw

Vertebrata:
- Undetermined tooth of fish.

Two miles below the preceding, about 10 miles below Eufaula, 25 or 30 feet of similar echinoid bearing rock with interbedded soft sand pockets and layers, appears in a bluff on the Georgia side of the river. The same species of Echinodermata were obtained here, also *Ostrea subspatulata* Forbes (variety) and *Cardium kümmeli* Weller.

At the mouth of Pataula Creek, 12¼ miles below Eufaula, Doctor Stanton collected the following fossils from typical marine materials:

Locality No. 855.—Chattahoochee River at mouth of Pataula Creek, Ga. T. W. Stanton, collector.

Mollusca:
- Nucula percrassa Conrad
- Nucula distorta Gabb ?
- Nucula eufalensis Gabb
- Leda pinnaforma Gabb
- Leda longifrons Conrad
- Leda sp. (cf. L. marlboroensis Weller)
- Perrisonota protexta Conrad
- Cucullaea littlei (Gabb)
- Breviarca cuneata (Gabb)
- Nemodon eufalensis Conrad
- Glycymeris subaustralis (d'Orbigny)
- Glycymeris ?
- Gervilliopsis ensiformis (Conrad)
- Gervilliopsis sp.
- Gryphaea vesicularis Lamarck
- Trigonia eufalensis Gabb
- Pecten argillensis Conrad
- Pecten argillensis Conrad
- Pecten simplicius Conrad
- Pecten tenuitestus Gabb
- Lima acutilineata (Conrad)
- Lima reticulata Forbes
- Anomia argentaria Morton
- Anomia sp. nov. (same as at "Narrows" of Pataula Creek)
- Pulvinites argentea Conrad
- Crenella serica Conrad
- Dreissensia tippana Conrad
- Pholadomya sp. nov. (same as at "Narrows" of Pataula Creek)
- Liopistha protexta Conrad
- Veniella conradi (Morton)
- Etea carolinensis Conrad
- Vetericardia crenalirata (Conrad)
- Crassatellites pteropsis Conrad
- Crassatellites eufalensis Gabb
- Crassatellites sp.
- Tenea pinguis (Conrad) ?
- Sphaerella concentrica Conrad
- Cardium eufaulense Conrad
- Cardium spillmani Conrad
- Cyprimeria alta Conrad (var. ?)
- Cyprimeria depressa Conrad
- Legumen planutatum (Conrad)
- Aphrodina tippana Conrad
- Aenona eufalensis Conrad
- Linearia metastriata Conrad
- Linearia sp.
- Leptosolen biplicata Conrad
- Cymbophora lintea (Conrad)
- Corbula crassiplica Gabb
- Corbula (several other species)
- Dentalium ripleyanum Gabb
- Pleurotomaria ?
- Lunatia obliquata Meek & Hayden
- Turritella sp. nov. (with two spiral ribs)
- Turritella sp.
- Sphenodiscus pleuriseptus (Conrad)
- Undetermined pelecypods and gastropods

Vertebrata:
- Dermal scute of gavial-like crocodile

(Identified by C. W. Gilmore.)

One mile below the mouth of Pataula Creek Dr. Stanton collected the following fossils:

Locality No. 859.—Chattahoochee River, one mile below the mouth of Pataula Creek. T. W. Stanton, collector.

Mollusca:
- Cucullaea littlei (Gabb)
- Glycymeris subaustralis (d'Orbigny)
- Exogyra costata Say
- Trigonia angulicostata Gabb
- Pholadomya sp. nov. (same as at "Narrows" of Pataula Creek.)
- Crassatellites sp.
- Cardium spillmani Conrad
- Cardium eufalensis Conrad
- Cardium tippanum Conrad
- Aphrodina tippana Conrad ?

Thirteen and one-half miles below Eufaula, and one and one-half miles above Othos Landing, on the Alabama side, the following section occurs:

Section 13 1/2 miles below Eufaula, and one and one-half miles above Othos Landing, right bank.

	Feet.
Tree-covered slope probably in part Eocene	50
Upper Cretaceous.	
Ripley formation. (*Exogyra costata* zone)	
2. Gray, coarsely arenaceous clay, with poor fossils, *Anomia argentaria* Morton recognized.. Brownish band a few inches thick along base	3
1. Gray marine sand alternating with numerous ledges of coarsely arenaceous limestone. Contains *Cassidulus subquadratus* Conrad, *Exogyra costata* Say, *Cardium kümmeli* Weller, and undetermined gastropods, about	25

Between the preceding locality and Morris Landing, 15 miles below Eufaula, indurated ledges were seen at intervals projecting from bluffs partially overgrown with vegetation, but no detailed observations were made until Morris Landing was reached. Somewhere in this distance the Cretaceous beds have passed finally beneath water level, for at Morris Landing only Eocene rock is exposed. The basal three feet here consists of partially indurated, calcareous, argillaceous sandstone containing numerous casts of *Turritella mortoni* Conrad and some other Eocene fossils. This is overlain by coarse, sandy limestone, which grades upward into white limestone, containing but little sand, the whole thickness amounting to about 20 feet.

Region between Chattahoochee and Ocmulgee rivers (typical marine beds).—Typical marine beds of the Ripley formation, referable to the zone of *Exogyra costata,* appear at the surface in a belt which extends from Chattahoochee River to the northeastward, including parts of Clay, Quitman, Stewart, Chattahoochee, Marion, Schley, and Macon counties. From Quitman County, southeast of Georgetown, to the northeastern extremity of their occurrence in Macon County, the beds are overlain by the Providence sand member of the formation.

Fossiliferous exposures have been studied at several localities in Quitman County. At the bridge of the Central of Georgia Railway over Mercers Mill Creek, one-half mile south of the station at Georgetown, there is exposed eight or ten feet of dark gray to black, finely arenaceous, micaceous sand containing bits of lignite and many fossils. (See plate XV, A, opposite p. 176.) Many of the species occurring here are small forms. They are for the most part pelecypods and gastropods. The following forms have been identified:

Locality No. 5417.—Mercers Mill Creek, Central of Georgia Railway bridge, near Georgetown, Ga. L. W. Stephenson, collector.

Protozoa:

Nodosaria sp.

Coelenterata:

Stephanophyllia (near bowerbankii M. E. & H.)
(Identified by T. W. Vaughan)

Vermes:

Serpula sp. (long, nearly straight tube)
Hamulus onyx Morton
Hamulus squamosus Gabb

Mollusca:

Nucula distorta Gabb ?
Nucula sp.
Breviarca cuneata (Gabb) ? (young)
Leda pinnaformis Gabb
Nemodon eufalensis Conrad
Glycymeris subaustralis (d'Orbigny)
Gervilliopsis ensiformis (Conrad)
Inoceramus sp.
Ostrea sp.
Gryphaea vesicularis Lamarck? (young)
Exogyra costata Say
Trigonia eufalensis Gabb
Pecten simplicius Conrad
Lima acutilineata (Conrad)
Lima reticulata Forbes
Anomia argentaria Morton
Anomia linifera Conrad
Crenella serica Conrad
Dreissensia tippana Conrad
Veniella conradi (Morton)
Vetericardia crenalirata (Conrad)
Crassatellites eufalensis Gabb
Scambula perlana Conrad
Lucina sp.
Tenea pinguis Conrad
Cardium kümmeli Weller
Cardium eufaulense Conrad
Aphrodina tippana Conrad
Aenoma eufalensis Conrad
Linearia metastriata Conrad
Cymbophora lintea (Conrad)
Corbula crassiplica Gabb
Corbula (several other species)
Dentalium ripleyanum Gabb
Dentalium sp.
Cadulus obnutus (Conrad)
Scala sillimani (Morton)
Rapana stantoni Weller
Eulima sp.
Pleurotoma ? melanopsis (Conrad)
Pleurotoma ? laqueata (Conrad)
Lunatia obliquata Meek and Hayden
Turritella trilira Conrad
Strepsidura interrupta Conrad
Morea cancellaria, Conrad
Volutoderma sp.
Cyclichna ?
Undetermined gastropods

Arthropoda:

Bairdro sp. (ostracod identified by R. S. Bassler)

The horizon exposed at Mercers Mill corresponds in vertical position to the upper part of the Cretaceous portion of the section in the bluff at Eufaula. The Cretaceous beds at this mill are overlain by Pleistocene terrace gravels as shown by exposures just to the east of the Central of Georgia Railway bridge.

On the Georgetown-Coffinton road, about six miles south of Coffinton, just south of a bridge over a small creek, materials are exposed as described in the following section:

Section in Georgetown-Coffinton road, six miles south of Coffinton, Quitman, County.

	Feet.
Pleistocene ?	
2. Yellow sand and loam with small fragments of limestone along base	15
(Unconformity)	

Upper Cretaceous.
Ripley formation (*Exogyra costata* zone)
1. Dark gray, marine clay 5

Fossils were obtained in the marine clay in the preceding section as follows:

Locality No. 5383.—Georgetown-Coffinton road, six miles south of Coffinton, Ga., and just south of bridge over small creek. L. W. Stephenson, collector.

Vermes:
Hamulus onyx Morton
Mollusca:
Ostrea larva Lamarck
Exogyra costata Say
Anomia argentaria Morton
Paranomia scabra (Morton)

The horizon at the preceding locality probably corresponds approximately to that at Mercers Mill described above.

In a cut of the Central of Georgia Railway five miles southeast of Eufaula, Ala., in Quitman County, Ga., the following section is exposed:

Section in cut of Central of Georiga Railway, five miles southeast of Eufaula, Ala., in Quitman County, Ga., near the 139th milepost.

Upper Cretaceous.	Feet.	In.
Ripley formation (*Exogyra costata* zone).		
6. Weathered, rather fine, harsh, micaceous, slightly argillaceous sand faintly tinted with red and pink, with iron crusts locally distributed and with a thin iron crust along base	10	
5. Fine, micaceous sand, similar to preceding, but looser in texture	2	6
4. Laminated, drab, finely arenaceous and micaceous clay with fine, micaceous sand partings, iron crusts along base	5	6
3. Yellow, loose, medium to fine, micaceous sand . .	5	
2. Gray, micaceous, argillaceous sand, with some clay films and occasional thin iron crusts . .	4	
1. Light gray, yellowish, coarse, somewhat micaceous sand, with irregularly developed ferruginous masses containing prints of fossils . Exposed 5 to 10 feet.		

From layer No. 1 in the above section the forms listed below have been identified:

Locality No. 6933.—One hundred and thirty-ninth milepost, Central of Georgia Railway, Quitman County, Ga. [about five miles southeast of Eufaula, Ala., L. W. S.]. Collector, Otto Veatch.

Mollusca:
Pecten sp.
Crassatellites pteropsis Conrad
Cardium kümmeli Weller
Cardium eufaulense Conrad ?
Cardium tippanum Conrad ?
Pugnellus sp.
Anchura sp.

The horizon from which the above listed forms was obtained is probably higher stratigraphically than the Mercers Mill exposure, and not so high as the Pataula Creek exposure described below.

An interesting section is exposed in Clay County at the "Narrows" of Pataula Creek, nine miles north of Fort Gaines, and two miles above the mouth of the creek. The so-called "Narrows" is a gorge about one-eighth mile long, cut in the Ripley formation, the gorge proper being some eight or ten feet deep and terminating up stream in a picturesque waterfall. The section given below was taken near the head of the gorge and shows the character of the materials in the gorge proper and in the slope above the level of the brink of the falls. (See Plate XVI, A and B.)

Section near head of gorge at the "Narrows" of Pataula Creek, nine miles north of Fort Gaines, Clay County, Ga.

	Feet.
Upper Cretaceous.	
Ripley formation (*Exogyra costata* zone).	
2. Brownish, weathered, argillaceous, marine sand .	12
1. Dark greenish gray, massive, micaceous, argillaceous, marine sand with indurated ledges 1 to 6 ft. apart. A few specimens of *Exogyra costata* Say observed, and near the base an abundance of decayed shells	23

Just below the mouth of the gorge, in a horizon slightly lower than the base of the preceding section, a large collection of well preserved fossils was obtained from a coarse sandy, shell marl. In the list of fossils given below those collected by the writer were from the marl just described, and those collected by Veatch were from parts of the section not designated. The beds exposed at the "Narrows" correspond to the exposure at and near the mouth of Pataula Creek on Chattahoochee River from which Dr. Stanton made exhaustive collections. (See pp. 179-180 of this report.)

Pataula Creek, Clay County, Ga., the "Narrows," two miles above junction with Chattahoochee River and nine miles north of Fort Gaines. Collectors, Otto Veatch and L. W. Stephenson.

A. THE "NARROWS" OF PATAULA CREEK, NINE MILES NORTH OF FORT GAINES, SHOWING TEN FEET OF CALCAREOUS MARINE SAND WITH INDURATED LAYERS OF THE RIPLEY FORMATION.

B. WATERFALL AT UPPER END OF THE "NARROWS" OF PATAULA CREEK, PRODUCED BY INDURATED CALCAREOUS LAYER AT TOP

	Locality Number.	
	O. V. 5376b	L. W. S. 6412
Echinodermata:		
Cassidulus porrectus Clark (identified by W. B. Clark)	x	
Vermes:		
Serpula sp. cf. (s. cretacea (Conrad)		x
Mollusca:		
Nucula percrassa Conrad		x
Nucula sp. *a* (cf. N. slackiana Gabb)		x
Nucula sp. *b*		x
Perrisonota protexta Conrad		x
Leda pinnaforma Gabb (var. ?)		x
Cucullaea sp.		x
Breviarca cuneata Gabb		x
Nemodon eufalensis Conrad (var. ?)		x
Glycymeris subaustralis (d'Orbigny)		x
Exogyra costata Say	x	x
Ostrea sp.		x
Trigonia angulicostata Gabb		x
Anomia argentaria Morton		x
Anomia sp. nov.		x
Pholadomya sp. nov.	x	x
Crassatellites pteropsis Conrad		x
Crassatellites sp.		x
Lucina swedesboroensis Weller ?		x
Lucina sp. nov.		x
Tenea pinguis Conrad		x
Cardium eufaulense Conrad	x	x
Cardium eufaulense Conrad (var. ?)		x
Cardium spillmani Conrad	x	
Cyprimeria depressa Conrad		x
Legumen planulatum (Conrad)		x
Aenona eufalensis Conrad		x
Linearia carolinensis Conrad ?		x
Linearia sp. nov.		x
Leptosolen biplicata Conrad		x
Cymbophora lintea (Conrad) ?		x
Corbula sp.		x
Undetermined pelecypods		x
Dentalium sp.		x
Eulima sp.		x
Solarium ?		x
Lunatia obliquata Meek & Hayden		x
Lunatia sp.	x	
Turritella trilira Conrad	x	
Turritella sp. nov. (two spiral ridges)		x
Pterocerella tippana Conrad		x
Anchura sp.		x
Ancilla sp.		x
Actaeonina sp.		x
Cylichna recta Gabb		x
Undetermined gastropods		x
Vertebrata:		
Corax falcatus Agassiz		x
Undetermined shark's tooth		x
Monotygma sp.		x

At Credilles Mill, Pataula Creek, about one mile above the "Narrows," Veatch collected the following fossils from a horizon probably slightly higher than the marl bed described in the preceding section:

Locality No. 5376a.—Credilles Mill, Pataula Creek, about one mile above the "Narrows," Clay County, Ga. Otto Veatch, collector.

Echinodermata:
 Cassidulus conoideus Clark (Identified by W. B. Clark)
Vermes:
 Serpula cretacea (Conrad
Mollusca:
 Cucullaea littlei (Gabb)
 Breviarca cuneata (Gabb)
 Glycymeris subaustralis (d'Orbigny)
 Cyprimeria depressa Conrad
 Volutomorpha sp.
 Undetermined gastropod

The beds exposed on Pataula Creek and on the river near the mouth of the creek are in stratigraphic position near the extreme uppermost part of the Ripley formation.

Typical marine beds of the formation are exposed at numerous localities in Stewart County.

About one and one-half miles east of Coffinton, in a deep gully just north of the road leading east to the Eufaula-Lumpkin road, the following fossils were collected from dark gray marine sands, with indurated layers, about 100 feet below the level of the road:

Locality No. 5382.—One and one-half miles east of Coffinton, Ga. Collector, L. W. Stephenson.

Mollusca:
 Ostrea subspatulata Forbes
 Exogyra costata Say
 Anomia argentaria Morton
 Baculites sp.

Above the fossil layer at the preceding locality the marine materials appear to grade up into fine, unconsolidated sand, which may represent the basal part of the overlying Providence sand member. The fossil horizon probably corresponds approximately to the horizon exposed at Mercers Mill in Quitman County, Ga. (see p. 182 of this report), anl at Eufaula, Ala. (see p. 175 of this report.)

The basal 40 feet of the section exposed in the deep gully near Providence postoffice (now abandoned), described on page 194 of this report, is made up of typical marine beds of the Ripley formation. Among the casts observed near the top of layer No. 1 in that section the following forms were recognized: *Serpula sp., Leda sp., Cucullæa sp.* (large), *Cardium sp.* (with spines), *Cardium eufaulense* Conrad (?), *Cyprimeria depressa* Conrad, *Leptosolen biplicata* Conrad, and *Turritella trilira* Conrad. In the shell layer at the base *Exogyra costata* Say and *Cyprimeria depressa* Conrad, were recognized.

Four miles north of Lumpkin the following interesting section is exposed where the road passes down a steep northward-facing slope known as Johnsons Hill.

Section, Johnsons Hill, Lumpkin-Louvale road, four miles north of Lumpkin.

	Feet.
Upper Cretaceous.	
Ripley formation (*Exogyra costata* zone).	
(Providence sand member).	
5. Reddish brown, rather fine, ferruginous, somewhat argillaceous, weathered sand. Grades downward into next layer	15
4. Weathered, pinkish, somewhat argillaceous, ferruginous sand	8
(Typical marine beds)	
3. Fine, greenish, micaceous sand, weathered in the upper part to pinkish and yellowish tints . . .	20
2. Fine, greenish gray, calcareous, more or less argillaceous, marine sand with indurated ledges about 6 inches thick, 2 to 5 feet apart. Fossiliferous. One specimen of *Pholadomya sp. nov.* 12 ft. below top	40
1. Dark gray, massive, argillaceous, calcareous sand, with indurated ledges similar to those in layer No. 2. Fossiliferous	22

The fossils listed below were obtained in layers Nos. 1 and 2 of the preceding section. The fossiliferous part of this section is probably approximately at the same stratigraphic level as the Cretaceous section of Eufaula, Ala., although the presence of the large *Pholadomya* may indicate a slightly higher horizon.

Johnsons Hill, Stewart County, Ga., four miles north of Lumpkin on Lumpkin-Louvale road. Collectors, Otto Veatch and L. W. Stephenson.

	Locality Number	
	O. V. 5375	L. W. S. 6418-a-j
Mollusca:		
Ostrea tecticosta Gabb		x
Ostrea plumosa Morton		x
Ostrea larva Lamarck var. falcata Morton		x
Gryphaea vesicularis Lamarck (varieties)		x
Exogyra costata Say	x	x
Exogyra costata var. cancellata Stephenson	x	x
Trigonia thoracica Morton ?		x
Pecten quinquecostatus (Sowerby)		x
Lima reticulata Forbes		x
Anomia argentaria Morton	x	x
Anomia sp.		x
Paranomia scabra (Morton)	x	x
Pholadomya sp. nov. (same as sp. nov. from Pataula Creek)		x
Turritella trilira Conrad		x

In the extreme northeastern corner of Stewart County the typical marine beds are well exhibited in a series of cuts of the Seaboard Air Line Railway from Renfroes Station northward for a distance of one and one-quarter miles.

At the north end of the first cut near the water tank the the following section was made:

Section in cut of Seaboard Air Line Railway, one-quarter mile north of Renfroes Station.

	Feet.
Upper Cretaceous.	
Ripley formation (*Exogyra costata* zone).	
(Providence sand member).	
5. Gray residual sand	3
4. Red, ferruginous, slightly indurated, rather coarse sand	4 to 7
3. Light gray, coarse, massive sand, partially mottled with yellow	5
2. Gray, pebbly, argillaceous sand with numerous small angular quartz pebbles up to one inch in diameter, poorly exposed	5
(Typical marine beds)	
1. Dark greenish gray, compact, massive, calcareous clay, resembling an impure phase of the Selma chalk of Alabama	4

From the cut just described northward for one mile there are a number of cuts exhibiting marine sands and clays. The track passes down a steep grade to the north. The thickness of strata exposed could not be determitned with exactness, but the beds are nearly horizontal, and it is probable that the amount does not exceed 60 or 70 feet. These are the type occurrences of the "Renfroes marl" of Veatch. The best section is furnished by the cut farthest north.

Section in cut of Seaboard Air Line Railway, one-quarter mile north of Renfroes Station.

	Feet.
Upper Cretaceous.	
Ripley formation (*Exogyra costata* zone).	
3. Weathered, yellow, fine, calcareous, sand with an indurated, calcareous, nodular layer 5 feet above base. Fossiliferous. One specimen of *Pholadomya sp. nov.* 10 feet above base	20
2. Gray, massive, calcareous, sandy clay, with an indurated, nodular, calcareous layer 3 feet above base. Resembles certain impure phases of the Selma chalk in Alabama. Fossiliferous	25
1. Massive, argillaceous, micaceous sand, apparently non-fossiliferous	7

The following list is compiled from collections obtained from the exposures in the several cuts from one-quarter to one and one-quarter miles north of Renfroes station. Most of the specimens were found

loose on the talus slopes, having weathered from the beds. On account of the mixing of the specimens on the talus slopes, and because all the species identified (with the exception of the new species of *Pholadomya* whose position in the section is indicated) are wide-ranging within the zone of *Exogyra costata,* no attempt is made to designate in which of the above described layers they were originally in place. The stratigraphic position of the beds exposed in these cuts probably corresponds approximately to the Cretaceous portion of the section at Eufaula, although the presence of *Pholadomya* sp. nov. may indicate a slightly higher position in the section for layer No. 3.

Cuts of Seaboard Air Line Railway, one-quarter to one and one-quarter miles north of Renfroes Station, Stewart County, Ga. L. W. Stephenson, collector.

Loc. Nos. 6413-6417.

Mollusca:

Cucullaea sp.
Ostrea tecticosta Gabb
Ostrea larva Lamarck
Ostrea plumosa Morton
Grymphaea vesicularis Lamarck (varieties)
Gryphaea sp. (small)
Exogyra costata Say
Exogyra costata var. cancellata Stephenson
Pecten quinquecostatus (Sowerby)
Pecten sp. nov. ?
Dianchora sp.
Lima reticulata Forbes
Anomia argentaria Morton
Paranomia scabra (Morton)
Paranomia sp. nov.
Pholadomya sp. nov (same as sp. nov. from Pataula Creek)

Vertebrata:

Ischyrhiza mira Leidy (Iden. by J. W. Gidley)

The typical marine beds of the formation have been penetrated in two wells in Stewart County. Information concerning the strata penetrated in these wells has been obtained from the owners, as follows:

G. L. Walton, of Charles, Ga., owns two wells; one, 65 feet deep, located near the station at the level of the track (Seaboard Air Line Railway), and another 85 feet deep, seven-eighths of a mile east of the station, 80 feet above the level of the track. Mr. Walton states that "the land is underlaid with hard marl and no one in the neighborhood has ever been able to carry a well through it."

Log of well owned by E. H. Acker, two miles southwest of Charles, Georgia.

	Feet.
Upper Cretaceous.	
Ripley formation. (*Exogyra costata* zone).	
3. Sand	0 to 10
2. Hard, dark brown, and gray, streaked clay, with one small layer of sand, water-bearing	10 to 26
1. Black marl at bottom of well	?
Total	26

Mr. Acker states that the black marl has been encountered in other wells in this neighborhood.

Mr. C. V. Stephens, of Renfroes, states that blue marl is encountered 10 to 15 feet below the surface in wells one and one-half miles west of Renfroes, and that wells 90 feet deep have failed to penetrate through this kind of material.

In Marion County weathered phases of the typical marine beds of the formation appear at intervals in the Buena Vista-Tazewell road, from two to four miles northeast of Buena Vista.

Prof. S. W. McCallie[1] has published the log of a deep well drilled at Buena Vista, which throws light on the character of the strata underlying the central part of the county. It is as follows:

Log of well at Beuna Vista, Ga.

	Feet.
Blue clays	0- 35
Sand and clays	35-105
Soft limestone	105-155
Marl	155-158
Rock	158-159
Marl	159-252
Flint	252-254
Indurated marl	254-263
Hard rock	263-270
Marl	270-297
Limestone (water-bearing)	297-331
Coarse gray sand	331-343
Marl (water-bearing)	343-364
Marl	364-551
Hard, compact rock	551-583

The upper 105 feet of strata described in the above log is referable to the Providence sand member of the Ripley formation, and the remainder of the section are typical marine beds of the same formation.

Professor McCallie has collected fossils in Marion County from marine materials in the *Exogyra costata* zone, as enumerated in the following lists:

Locality No. 3052.—Bivens Plantation on Dry Creek, three miles west of Pineville, Marion County, Ga. S. W. McCallie, collector.

Mollusca:

- Ostrea tecticosta Gabb
- Gryphaea vesicularis Lamarck
- Exogyra costata Say
- Exogyra costata var. cancellata Stephenson
- Anomia argentaria Morton
- Paranomia scabra (Morton)
- Cardium sp.

[1]Geol. Surv. of Ga., Bull. No. 15, 1908, p. 146.

Locality No. 3053.—Lanneyhassey Creek, four miles south of Buena Vista, Marion County, Ga. S. W. McCallie, collector.

Mollusca:

Cucullaea sp.	Pecten argillensis Conrad
Inoceramus sp.	Cardium eufaulense Conrad ?
Exogyra costata Say	Panopea decisa Conrad

Locality No. 3054.—Cut in public road near Central of Georgia Railway bridge across Ninchafoonee creek, five miles northwest of Buena Vista, Marion County, Ga. S. W. McCallie, Collector.

Mollusca:

Veniella sp. (cf. sp. from Hodges old mill, S. C.)
Cardium (Trachycardium) alabamense Gabb
Aphrodina sp.
Turritella trilira Conrad

Fossils have been collected from typical marine beds of the formation at one place in Schley County. This locality is at the water mill of J. L. B. Usry, seven miles north of Ellaville and one-half mile east of Murray Crossroads. The fossils were obtained just below the west end of the milldam from a poor exposure of light green to greenish yellow, massive, marine sand, indurated in layers at the water's edge, and one foot above the water's edge. The remains consist of very soft shells and shell prints. The forms listed below were recognized:

Locality No. 6482.—List of fossils from J. L. B. Usry's mill, seven miles north of Ellaville, Ga., and one-half mile east of Murray Crossroads. L. W. Stephenson, collector.

Mollusca:

Nemodon sp.	Paranomia scabra (Morton)
Ostrea plumosa Morton	Pholadomya sp.
Gryphaea vesicularis Lamarck (small)	Lucina sp.
Exogyra costata Say (small, but apparently typical)	Tenea ?
Pecten argillensis Conrad ?	Cardium spillmani Conrad
Pecten simplicius Conrad	Cardium sp.
Lima sp.	Legumen planulatum (Conrad)
Pecten quinquenarius Conrad	Turritella trilira Conrad
Anomia argentaria Morton	Undetermined pelecypods
	Corbula crassiplica Gabb

The farthest locality to the eastward at which the typical marine Ripley beds have been observed is in a cut of the Atlanta, Birmingham & Atlantic Railroad, one and one-eighth miles north of Ideal, Macon County. The section exposed here is described below: (See also plate XII, B.)

Section in cut of Atlanta, Birmingham & Atlantic Railroad, one and one-eighth miles north of Ideal, Ga.

	Feet.	In.
Upper Cretaceous.		
Ripley formation. (*Exogyra costata* zone.)		
7. Loose, yellow, pebbly sand, probably creep	4	
6. Yellow massive fine, micaceous, argillaceous sand, a weathered marine sand	7	
5. Gray, laminated, micaceous, sandy, marine clay, with fine sand partings	4	
4. Weathered, fine, yellow, argillaceous, marine sand	8	
3. Iron crust		½
2. Dark, gray, finely arenaceous and micaceous, compact clay, weathering somewhat shaley. Contains poor prints and casts of fossils	20	
1. Dark gray to yellow, massive, marine sand with numerous fossil prints at south end of cut . . .	4	

The fossils listed below were obtained from layers Nos. 1 and 2 in the above section.

Locality No. 6483.—List from cut of Atlanta, Birmingham & Atlantic Railroad, one and one-eighth miles north of Ideal, Ga. At base of layer No. 2. L. W. Stephenson, collector.

Mollusca:

- Cucullaea vulgaris Morton ?
- Crassatellites sp.
- Crassatellites pteropsis Conrad
- Cardium spillmani Conrad
- Cardium sp.
- Cyprimeria depressa Conrad
- Cyprimeria densata (Conrad)
- Aphrodina sp.
- Cymbophora lintea (Conrad) ?
- Turritella trilira Conrad

Vertebrata:

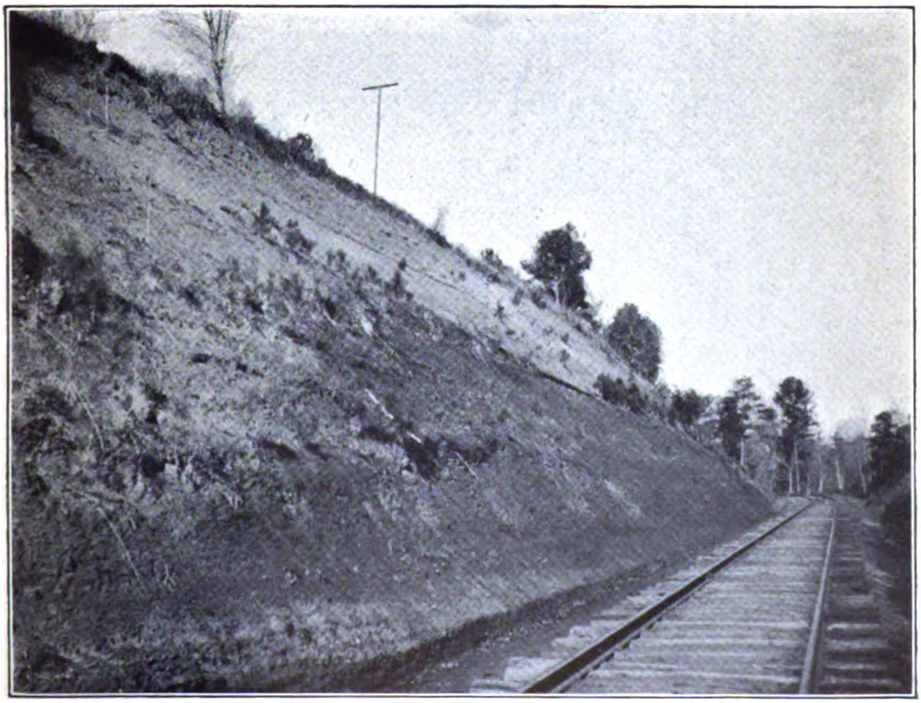
- Lamna texana Roemer
- Corax falcatus Agassiz
- Otodus appendiculatus Agassiz?
- Fragments of bones
- Tooth of mosasauroid reptile (Ident. by C. W. Gilmore)

At Marshallville in the eastern part of Macon County, beds which probably represent the eastward buried extension of the typical marine beds have been penetrated in a well boring. (See section, p. 197 of this report.)

Region between Chattahoochee and Ocmulgee rivers (Providence sand member).—Westward from Chattahoochee River in Alabama, and northeastward from the river in Georgia, the uppermost of the typical marine beds of the Ripley formation merge into shallow water equivalents. These strata constitute the Providence sand of Veatch. In this report they are treated as a member of the Ripley formation.

The points farthest south in Georgia where the Providence sand has been observed are in two cuts of the Central of Georgia Railway, five and three-quarters and six miles, respectively, southeast of Eufaula, Ala., in Quitman County, Ga. The first cut reveals 20 or 25 feet of coarse, irregularly bedded, reddish and yellowish sands

A. CUT OF SOUTHERN RAILWAY ONE-THIRD MILE NORTH OF ZENITH STATION, CRAWFORD COUNTY, SHOWING CONTACT BETWEEN THE RIPLEY FORMATION AND SAND OF PROBABLE EOCENE AGE.



B. CUT OF ATLANTA, BIRMINGHAM & ATLANTIC RAILROAD, ONE AND ONE-EIGHTH MILES NORTH OF IDEAL, MACON COUNTY, GA., SHOWING MARINE SANDS AND CLAYS OF THE RIPLEY FORMATION.

with iron crusts at intervals. The base of the sands of this character is not clearly revealed, but the relations are such as to show conclusively that they occupy a stratigraphic position closely above the uppermost of the marine beds in the section three-quarters of a mile northwest of this point, described on page 183.

The second cut, six miles from Eufaula, reveals the contact between the Providence sand member and the overlying Eocene beds. The relation between these divisions are shown in Fig. 13.

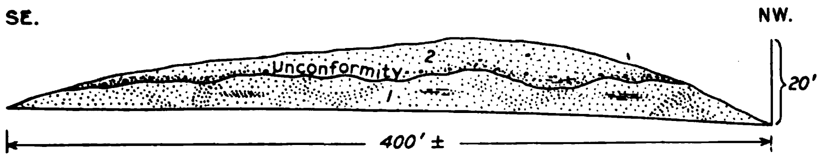


Fig. 13.—Section in cut of Central of Georgia Railway, six miles southeast of Eufaula, Ala., in Quitman County, Ga.

Explanation of Figure.

Eocene.

2. Deep red, ferruginous, coarse sand massive in appearance in upper weathered portion; lighter in color, coarser, and showing some crossbedding along base; in lower 2 or 3 feet contains reworked clay balls, iron crusts, and in places angular quartz pebbles up to 2 inches in diameter.

Upper Cretaceous.

Ripley formation (Providence sand member)

1. Coarse, crossbedded, light gray, yellowish and pinkish sand with subordinate lenses of drab, pinkish, coarsely sandy, massive clays.

Layers 8 to 15 inclusive in the section at Stewarts Hill on Chattahoochee River, five and one-half miles above Eufaula in Quitman County, Ga., described on page 174, probably represent the transition from the typical marine beds of the formation to the overlying Providence sand member.

An excellent exposure of the Providence sand member is furnished by a deep gully to the west of the Eufaula-Lumpkin road, 10½ miles northeast of Georgetown, Ga. According to aneroid estimates the elevation of the road at this point is about 350 feet above the floor of the wagon bridge at Eufaula. The gully which is down the slope to the west of the road, exposes about 100 feet of materials consisting principally of coarse, crossbedded, varicolored sands with occasional clay lenses. The sands in places contain numerous small clay balls and one layer of large clay boulders was observed. Occa-

sional iron crust layers occur. The base of the section is about 130 feet below the level of the road. (See plate XVIII, A.)

The most complete section of the Providence sand member is furnished by a series of deep gullies near Providence, an abandoned postoffice eight miles a little north of west of Lumpkin. This is the type locality for this division. One of the gullies just south of the Lumpkin-Florence road shows the relation of the division to the overlying Eocene beds. The section follows:

Section in gully south of Lumpkin-Florence road near Providence P. O. (now discontinued), eight miles a little north of west of Lumpkin, in Stewart County, Ga.

	Feet.
5. Dark red, sandy loam with iron crusts at base	15
(Unconformity)	
Upper Cretaceous.	
Ripley formation.	
(Providence sand member.)	
4. Irregularly bedded, white, yellow, red and purple, fine to medium grained sand, somewhat argillaceous in places	120
3. Yellow, argillaceous sand, becoming more argillaceous towards base. Conformably overlies the next layer below	10
(Typical marine beds).	
2. Dark gray, thinly laminated, finely arenaceous and micaceous clay. Contains some bits of lignite and small bits of amber	15
1. Dark greenish gray, micaceous, slightly argillaceous and glauconitic sand, with numerous soft fossil casts in the upper part and with shells in the lower 2 or 3 feet	25

On the hill slope above the top of the preceding section there are poor exposures of white Eocene limestone containing poorly preserved fossils. A similar limestone outcrops in the road, two or three miles to the east towards Lumpkin.

In a cut of the Seaboard Air Line Railway, just east of the station at Lumpkin, Stewart County, the supposed top of the Providence sand, consisting of several feet of light-colored, very sandy clay, is seen, overlain by four to six feet of iron-stained ferruginous clay bearing a few very poorly preserved shell impressions, the latter regarded as the base of the Eocene.

Northward from Lumpkin on the Lumpkin-Louvale road, there are numerous exposures in which the beds of this formation appear. The following section was made in an abandoned railroad cut, one and one-half miles north of Lumpkin:

Section in abandoned railroad cut just west of Lumpkin-Louvale road, one and one-half miles north of Lumpkin, Ga.

	Feet.
Eocene ?	
2. Reddish brown, ferruginous, coarse sand	20
(Unconformity, undulating, slightly irregular, sharp contact, marked in places by a thin iron crust.)	
Ripley formation.	
(Providence sand member.)	
1. Variegated, white, yellow, pink, red and purple, very coarse sand, crossbedded and loose, where locally indurated to ferruginous sandstone . .	30

The supposed Cretaceous-Eocene contact in the section just described is about 70 or 75 feet below the general upland level.

To the north of the preceding section the road is over deep red, compact, ferruginous sand, probably referable to the Eocene, to a point two and one-half miles north of Lumpkin, where it passes into coarse, light-colored, loose sands residual from the Providence sand.

At three and three and one-half miles, respectively, north of Lumpkin, the coarse, crossbedded sands of the Providence sand member are well exposed in gullies about 50 or 60 feet in depth.

No detailed observations were made along the Seaboard Air Line Railway south of Renfroes. However, between Renfroes and Brooklyn the coarse sands of the Providence member were seen from the train in shallow cuts and in gullies on the hill-slopes. Between Brooklyn and Richland the sub-soil for the greater part of the distance is red, and has the characteristic appearance of the basal Eocène beds of the region.

The logs of a number of wells in Stewart County which penetrate Cretaceous strata are given below. In each case the authority for the lithology is the owner unless otherwise stated.

Log of well owned by W. S. Boyett, four miles south of Lumpkin, Ga.

Eocene ?		
5. Red clay	0- 30	
Upper Cretaceous.		
Ripley formation. (Providence sand member.)		
4. "Chalk" (clay) white and pink		?
3. Coarse sand with small rock (pebbles)		?
2. "Chalk" (clay)		?
1. Thick layer of white sand		?
("and so on until water was struck.")		
Total		70

In another well 132 feet deep, located 25 yards from the preceding, water was obtained in coarse sand 128 to 132 feet below the surface. It is probable that all the strata penetrated in this well below the red Eocene clay should be referred to the Providence sand member.

Log of well owned by Mrs. Marion Glenn, one mile southeast of Brooklyn, Ga. Authority for lithology, J. M. Glenn, of Brooklyn.

Eocene.	
4. Red clay with gravel rock (pebbles)	0 - 30
Upper Cretaceous	
Ripley formation (Providence sand member).	
3. "Chalk" (clay)	30 - 40
2. White and yellow sand and occasionally a bed of rock four to five feet thick, water-bearing at base	40 - 110
1. Stopped in "chalk" (clay)	?
Total	110

A 140-foot well located 50 feet from the preceding is said to have penetrated similar materials.

Log of well owned by E. M. Averett, one-quarter mile east of Renfroes, Ga. Authority for lithology, C. V. Stephens, of Renfroes, Ga.

	Feet.
Upper Cretaceous.	
Ripley formation. (Providence sand member ?)	
4. Sand, gray or white	0- 8
3. Light yellow, firm clay	8-26
2. Soft, yellow sand	26-56
1. Sand and clay, water-bearing	56-60

Coarse, light-colored sands and clays of the Cusseta sand member of the formation appear in cuts and in other exposures in the immediate vicinity of Buena Vista, Marion County.

The supposed contact of the Providence sand member with the overlying Eocene is seen in a cut of the Central of Georgia Railway, one mile southeast of Buena Vista. (See plate XVIII, B, opposite p. 208.) The section here is as follows:

Section in cut of Central of Georgia Railway one mile southeast of Buena Vista, Ga.

	Feet.	In.
Eocene ?		
5. Dark red, massive sand with a line of small pebbles and iron crusts, 1½ feet above base	9	6
4. Irregular layer of iron crusts and botryoidal iron concretions with some admixture of argillaceous sand, average	1	
3. Light drab clay mottled with yellow, with irregular patches of yellow limonitic clay along base	3	
2. Slightly undulating iron crust		14
(Unconformity ?)		
Upper Cretaceous ?		
Ripley formation. (Providence sand member.)		
1. Light drab, massive clay, mottled with yellow and purple, containing irregular iron concretions	5	

The Providence sand outcrops in Schley County in a belt two or three miles wide extending east and west just north of the center of the county. Little is known of the details of its occurrences.

In Macon County the underlying typical marine beds of the formation are believed to merge finally into materials of the Providence sand type, at least so far as surface outcrops are concerned. Beyond this county to the eastward the Providence sand makes up the entire thickness of the *Exogyra* costata zone, the beds resting directly and conformably upon the Cusseta sand member of the formation.

The supposed contact of the formation with the superjacent Eocene beds was observed at an exposure at Barrows Mill, about four and one-half miles east of Marshallville. (See Fort Valley soil map, one and one-fourth miles southeast of Willow Lake, in square bearing the number 161.)

Section at Barrows Mill, Houston County.

Eocene	
3. Reddish, sandy loam (weathered)	3
2. Brownish, argillaceous sand and sandy clay, dark to black where unweathered, containing Eocene fossils	4
(Unconformity ?)	
Upper Cretaceous.	
Ripley formation (Providence sand member) ?	
1. Light gray, very coarse, very arkosic sand, streaked in places with yellow	8

A well owned by the town of Marshallville in Macon County, penetrated strata referable to the Ripley formation, from a depth of 25 feet to the bottom. The log given below was furnished by the contractor, Mr. M. N. Brewer. It is copied from Bulletin No. 15 of the Geological Survey of Georgia, 1908, p. 145.

Log of well at Marshallville, Ga.

	Feet.
10. Yellow clay	1- 25
9. Sand with some pipe clay	25- 90
8. Fine gray sand	90-185
7. Brownish sandy clay	185-230
6. Fine gray sand	230-270
5. Sand and blue marl	270-320
4. Clay	320-370
3. Thin layers of limestone	370-380
2. Very hard rock	380-390
1. Sand (water-bearing)	390-397

The upper 25 feet of the materials described in the preceding well should probably be referred to the Eocene. The beds from 25 to 370 feet probably belong to the Providence sand member of the Ripley formation; those from 370 to 397 are believed to form the eastward buried extension of the typical marine beds of the Ripley formation.

Veatch, in his clay report, pp. 209-211, and 215-217, has described Cretaceous clay deposits in Houston County, a part of which are believed to be referable to the Providence sand member. The following are quotations from his report:

"In Houston County notable deposits of white clay were observed in the vicinity of Perry, Fort Valley, and Byron. With the exception of clay mining at Perry, there are no clay industries in the county, and the clay deposits are undeveloped.

"*Perry*—A deposit of kaolin occurs on the Yancey property on Bay Creek, two miles northwest of Perry. This clay was described by the writer in Bulletin 315 of the United States Geological Survey, but since the above description was written a small mine has been opened up and the property to some extent developed * * *. The clay bed at the point mined has shown a maximum thickness of 18 feet. The clay is soft, massive bedded and jointed, though the jointing is not as extensive as in the Dry Branch region, and slickensided surfaces along the joint planes were not observed. The bed upon the whole is very free from sandy impurity, but it may grade into or be replaced by sand, and may be split by sand layers. * * *

"The overburden consists of very fine variegated, quartz and micaceous sands which will show a maximum thickness of about 80 feet.

"A pocket of white clay was noted on the Macon road, 5 miles northeast of Perry. The clay is exposed in a gully along the public road near the crossing of Mossy Creek. The deposit, owing to its inaccessibility, is of no value at present, but is instructive in showing the geological occurrence of the white clays of the Upper Cretaceous (?). The deposit is lens-shaped or cigar shaped, having a maximum thickness in the center, and tapering at each end; the full extent of the bed can be observed. The bed is about 100 feet in length, and has a maximum thickness of 8 feet and is overlain and underlain by red sand. Doubtless numerous other outcrops of white clay may be found eastward from Perry.

"*Bonaire.*—Bonaire is located on the Georgia Southern and Florida Railroad in the eastern part of Houston county, and is about 23 miles south of Macon. A deposit of white clay lying about four miles southeast of this place, on the property of Chas. Thompson, has attracted some attention on account of the conspicuousness of the outcrop. The clay is exposed at the base of a steep bluff bordering the Ocmulgee River swamp, and the bed is laid bare by the water flowing from a rather bold spring above it. The following is a vertical section of the bluff:

6.	Loose, brown sand	6
5.	Thin, drab clay layer	3
4.	Red sand	4
3.	White stained clay	4
2.	White sand	15
1.	White stained clay	10+

"The clay bed, No. 1, is semi-hard, bluish white, with purplish and yellow stains of iron oxide, which seem to permeate the mass of the clay and are not merely surface stains. Doubtless a greater thickness than is shown above, will be found; the lateral extent of the bed has not been determined, but no natural exposure of it were seen either to the north or to the south of the outcrop at the spring. It is believed the strata here belong to the Upper Cretaceous sands, a characteristic of which is lens-shaped beds of clay, rather restricted in area."

The logs of several wells in this county which are believed to penetrate strata of the Providence member are given below. The owners are authority for the lithology, except as otherwise indicated.

Log of well owned by T. W. Leverett at Wellston, Ga.

	Feet
Pleistocene ?	
2. Stiff, hard, red clay, about	0-40
Upper Cretaceous ?	
Ripley formation (Providence sand member)	
1. Coarse sand with numerous flint rocks (pebbles) as large as end of the thumb, water-bearing in lower eight feet	40-68

Log of well owned by J. A. Smith, three and one-half miles west of Wellston, Ga.

	Feet.
Eocene ?	
2. Solid red clay	0-20
Upper Cretaceous	
Ripley formation (Providence sand member)	
1. Yellow and white sand, in part fine alternating with "chalk" (clay), water-bearing in sand in lower 3 feet	20-93

Log of well owned by W. A. Stubbs and one-half miles east of Wellston, Ga.

	Feet.
Eocene ?	
2. Hard red clay	0-25
Upper Cretaceous	
1. Alternating beds of "chalk" (clay) and sand of various colors, white, bluish, yellow, etc., water-bearing below 207 feet	25-216

Doubtless all of the sand and clay beds included in division No. 1 of the above log are referable to the Upper Cretaceous. The upper part of the division is believed referable to the Providence sand member of the Ripley formation, but it is probable that at some depth the well entered the upper strata of the subjacent Cusseta sand member of the formation, the latter forming the basal portion of the section and furnishing the water-bearing material.

Log of well owned by T. N. White, three miles south of Dunbar, Ga.

	Feet.
Eocene ?	
2. Red clay	0-20
Upper Cretaceous	
1. White sand, except two layers of "chalk" (clay) each one foot thick, water-bearing in lower 3 feet	20-106

Log[1] of well at Perry, Ga.

	Feet.
6. Red massive clay	0-10
5. White clay	10-10½
4. Yellowish sand, with 4 inches of impervious iron at its base	10½-50
3. Sand with thin partings of clay	50-132
2. Dark carbonaceous materials—possibly lignite	132-136
1. Coarse gravel at	136

[1]Geol. Survey of Georgia Bull. No. 15, 1908, p. 121.

An undetermined upper portion of the section just described is referable to the Eocene, but the greater part of the section belongs to the Providence sand member of the Ripley formation.

DETAILED SECTIONS. (WELLS SOUTH OF THE BELT OF OUTCROP.)

At a number of places in Georgia well borings have been made that have passed through overlying Tertiary beds, entering and penetrating to various depths the beds of the Ripley formation beneath. Few reliable records have been kept, however, and the available information if meager. A well at Albany, Dougherty County furnishes the most instructive section of any yet recorded from the region. The log of this well was furnished by Mr. C. W. Tift, of Albany. The fossils, also furnished by Mr. Tift, were determined by Dr. T. Wayland Vaughan. This log was published in Bulletin No. 15 of the Geological Survey of Georgia, 1908, pp. 98, 99. It is here repeated, and in addition an attempt is made to correlate the Cretaceous portion of the section with the Cretaceous formations outcropping at the surface to the northward in the State. The writer has examined a part of the Cretaceous fossils obtained from the well and has made one or two slight changes in the determinations.

Log of City Artesian Well No. 2, Albany, Ga.

		Feet.
Tertiary:		
35.	Red clay	0- 20
34.	Light colored clay	20- 23
33.	Coarse sand (Vicksburg)	23- 25
32.	Light colored clay and coarse quartz sand	25- 35
31.	Limestone, *Orbitoides* sp. at 150 feet, and from 190 to 200 feet	35-200
30.	Gray limestone, *Orbitoides* sp., Echinoid, Bryozoa, *Terebratulina lachryma* (Morton), some shale from 230 to 240 feet	200-280
29.	Gray sand with comminuted shells (*Ostrea*) . .	280-285
28.	Some shale, coarse sand, shell, and sharks' teeth, at	311
27.	Hard layer, *Ostrea divaricata* Lea	318-320
26.	*Ostrea divaricata* Lea at	330
25.	*Ostrea alabamiensis* Lea at	340
24.	Shale or marl, water vein at	350
23.	*Ostrea divaricata* Lea and *Ostrea alabamiensis* Lea at	363
22.	Bed of lignite at	367
21.	Bed of lignite at	400
20.	Sand	400-475
19.	Stiff blue clay Echinoid spines, *Lamna* sp. (teeth)	470-475
18.	Stiff blue clay	475-480
17.	Hard gray sandstone	485-488
Upper Cretaceous		
Ripley formation.		
16.	*Ostrea* sp. and *Exogyra costata* Say ?	500-510
15.	Pyrite and small oysters at	520

14.	Greensands and greenish micaceous shales . . .	530-540
13.	Gray sand with black particles at	600
12.	Water-bearing horizon, limestone, with pieces of nard gray sandstone between 785 and 790 feet .	690-790
11.	Hard rock	790-800
10.	Clay shales, white limestone between 835 and 840	800-850
9.	Limestone, shales, etc. At 880 feet limestone or calcareous sand, also light gray micaceous sand	850-890
8.	Grayish sand, calcareous, fragments, hard black pieces of pebbles, *Ostrea* sp., *Anomia argentaria* Morton. [*Gryphaea vesicularis* Lamarck (young)] at 890 feet; water-bearing micaceous stone between 920 and 930 feet	890-940
7.	Blue, micaceous clay at 950 feet, thick shelled oyster, *Gryphaea* sp., the same also at 1,080 feet; at 1,100 feet gray sand with *Ostrea subspatulata* Forbes, *Exogyra costata* Say	940-1100
6.	Stiff blue clay, micaceous sandstone, *Ostrea cretacea* Morton (?)	1100-1200
5.	Very stiff blue clay, at 1255 feet, streaks of sand and shells, a small flow of water; from 1240 to 1260 soft shiny blue clay	1200-1260
4.	Marl, gray sand, sandstone lumps	1260-1270
3.	Gray and black sand, sandstone lumps	1270-1310
2.	Black, irregular, water-worn pebbles with hard crystalline fracture; coarse and fine quartz sand, shells, decayed wood, third water-bearing stratum; 50 gallons per minute	1310-1315
1.	Well ends in quartz sand at.	1320

A well at Blakely, in Early County, entered the upper beds of the formation at some depth between 160 and 500 feet, but probably nearer the latter depth. The log was furnished by Mr. S. S. Chandler and the fossils were determined by Dr. T. Wayland Vaughan. This log was published in Bulletin No. 15 of the Geological Survey of Georgia, 1908, pp. 105, 106. It is here repeated.

Log of town well, Blakely, Early County, Ga.

		Feet.
14.	Red, sandy clay	1- 10
13.	Coarse, grayish sand	10- 20
12.	Coarse, light-yellowish sand	20- 30
11.	Yellowish cherty limestone (Vicksburg)	30- 40
10.	Yellowish, or grayish, sandstone	40- 50
9.	Light-colored, almost white, calcareous sandstone, probably base of Vicksburg	50- 70
8.	Gray sands, darker at bottom	70-140
7.	Greenish sands, with *Ostrea divaricata* Lea . . .	140-160
6.	Fine gray sand, hard ledge at bottom	160-285
5.	Fine sand, with some clay	285-290
4.	Bluish clay	290-490
3.	Quartz sand, with glauconite	490-500
2.	Hard sandstone with glauconite. Two oysters, apparently *Gryphaea* sp. and *Exogyra costata* Say	500-510
1.	Grayish or bluish sands	510-580

Mr. George R. Irwin, of Fort Gaines, Ga., has furnished the following log of a well drilled by S. S. Chandler, in August, 1909, in Henry County, Alabama, two and one-half miles northwest of Fort Gaines, Ga. The writer is authority for the attempted correlation:

Log of well owned by George R. Irwin, located two and one-half miles northwest of Fort Gaines, Ga., in Henry County, Ala., on Chattahoochee River bottom, 700 yards west of the river at an elevation of 15 feet above high water mark.

		Feet.
Pleistocene (terrace deposit).		
17.	Clay and sand	1- 30
Eocene.		
16.	Soft lime rock	30- 75
15.	Hard lime rock	75-125
14.	Marl	125-135
13.	Hard lime rock	135-140
12.	Marl	140-170
11.	Coarse sand	170-180
Upper Cretaceous.		
Ripley formation.		
10.	Hard sand rock (or indurated sand)	180-186
9.	Coarse sand	186-190
8.	Hard sand rock (first flow of 10 to 11 gallons per minute at this depth measured from top of pump 7 feet above the surface)	190-196
7.	Coarse sand	196-202
6.	Hard sand rock	202-207
5.	Coarse sand	207-210
4.	Sand rock	210-212
3.	Coarse sand	212-215
2.	Marl	215-217
1.	Hard sand rock with some soft spots. At 230-235 feet the second flow of 25 to 30 gallons per minute was found, flowed this amount from top of 6-inch pipe. Well stopped in the rock	217-240

A number of flowing artesian wells have been drilled at Montezuma. The log of the deepest of these has been published in Bulletin No. 15 of the Geological Survey of Georgia, 1908, p. 142. The log was furnished by Mr. E. J. Wilson, the contractor. It is as follows:

		Feet.
18.	Sand to	6
17.	White clay to	18
16.	Limestone to	20
15.	Sand and clay to	50
14.	Bluish tough clay to	60
13.	Sand with mica to	75
12.	Blue clay to	95
11.	Sand and blue clay to	155
10.	Fine, micaceous sand to	160
9.	Sand and clay to	190
8.	Sand with thin layers of flint to	310
7.	Clay and fossil wood to	350
6.	Limestone containing shells to	352

5.	Micaceous sand to	356
4.	Clay interstratified with sand to	416
3.	Fossiliferous limestone with layers of sand to	480
2.	Clay to	496
1.	Sand to	500

No fossils were observed from the above described well and an attempt to distinguish the formations penetrated can be nothing more than a rough guess based upon the descriptions of the materials as furnished by the driller. Layer No. 18 is probably Pleistocene terrace sand; layers 10 to 17 inclusive probably belong to the Eocene; layers 1 to 9 probably include representatives of the Providence sand and the typical marine beds of the Ripley formation. If these correlations are correct the two water-bearing strata referred to by Prof. McCallie at 60 and 150 feet, respectively, are Eocene horizons, and those at 350 and 500 feet, respectively, are Ripley Cretaceous horizons.

An oil-prospecting well, located three and one-half miles southwest of Louisville, in Jefferson County, penetrated Cretaceous strata in part. The log is given on page 107 of this report. Fossils characteristic of the Claiborne group of the Eocene were obtained at a depth of 250 feet. A fragment of a turtle plate, supposed to be referable to the Upper Cretaceous, was obtained at a depth of 380 feet. On the basis of these fossils the contact between the Cretaceous and Eocene is believed to be somewhere between the depths indicated, and it is here tentatively placed at 350 feet. Crystalline basement rocks were encountered at 1,140 feet. The probable total thickness of Cretaceous strata penetrated, therefore, is 790 feet.

The data obtained from the Louisville well was insufficient to permit distinguishing between Upper and Lower Cretaceous strata, but it is believed that beds of both ages are represented. Doubtless the lower 500 or 600 feet of the Cretaceous portion of the section should be referred to the Lower Cretaceous and the remainder to the Upper Cretaceous, perhaps to the Ripley formation.

Wells at Arlington and Leary in Calhoun County, at Dawson in Terrell County, at Cuthbert in Randolph County, at Fort Gaines in Clay County, at Richland in Stewart County, at Americus in Sumter

County at Oglethorpe in Macon County, at Perry in Houston County, at Byromville in Dooly County, at Cordele in Crisp County, and at Dublin in Laurens County, and perhaps at other places, are of sufficient depth to pass through the Eocene deposits and enter the underlying Cretaceous beds. However, either no logs have been kept, or, in cases where logs have been recorded, the information given is too indefinite to permit discriminating between Eocene and Cretaceous beds. Such detailed information as is known concerning these wells has been published by Prof. S. W. McCallie in Bull. No. 15 of the Geological Survey of Georgia.

CORRELATION

The typical marine beds of the Ripley formation in Georgia are very prolific in fossil invertebrates. On the basis of the ranges of two species of *Exogyra* the formation has been divided into two parts. The first part embraces the lower one-third or one-half of the formation and forms the upper part of the zone of *Exogyra ponderosa,* of which the lower portion is the Tombigbee sand member of the Eutaw formation. The second part, embracing the remainder of the formation, is characterized by the presence of *Exogyra costata* and is designated the *Exogyra costata* zone. These two parts will be considered separately.

Part of Ripley formation included within the zone of Exogyra ponderosa. Omitting numerous forms identified generically but not specifically, and an occasional form whose specific identification is questioned, 34 species of invertebrates have been recognized in these beds, as follows:

1. Hamulus onyx Morton (Rc. Tp.)
2. Nucula percrassa Conrad (Rc. Tp. Eb.)
3. Cucullaea carolinensis (Gabb) (Tp.)
4. Trigonoarca sp. nov. (Roods Bend)
5. Nemodon brevifrons Conrad
6. Barbatia lintea Conrad (Tp.)
7. Ostrea plumosa Morton (Rc. Tp.)
8. Ostrea tecticosta Gabb (Rc.)
9. Ostrea sp. nov. (large, Roods Bend, etc.)
10. Gryphaea vesicularis Lamarck (Rc.)

11. Exogyra ponderosa var. erraticostata Stephenson (Tp.)
12. Trigonia sp. nov. (same as sp. nov. from Snow Hill, N. C.)
13. Pecten burlingtonensis Gabb (Tp.)
14. Pecten quinquenarius Conrad (Rc.)
15. Pecten sp. nov. (same as sp. nov. from Snow Hill, N. C.) (Tp. Eb.)
16. Anomia argentaria Morton (Rc. Tp.)
17. Anomia lintea Conrad
18. Anomia sp. nov. (same as sp. nov. from Snow Hill, N. C.) (Tp. Eb.)
19. Veniella conradi (Morton) (Rc. Tp.)
20. Crassatellites carolinensis Conrad ? (Tp.)
21. Crassatllites sp. nov. (Roods Bend, etc.)
22. Lucina glebula Conrad (Tp.)
23. Cardium eufaulense Conrad (Rc. Tp.)
24. Isocardia cliffwoodensis Weller ?
25. Cyprimeria depressa Conrad (Rc. Tp. Eb.)
26. Cyprimeria densata (Conrad) (Rc.)
27. Aphrodina regia Conrad
28. Cyclothyris alta Conrad (Tp.)
29. Legumen planulatum (Conrad) (Rc. Tp.)
30. Baroda carolinensis Conrad
31. Leptosolen biplicata Conrad (Rc. Tp. Eb.)
32. Cymbophora lintea (Conrad) (Rc. Tp. Eb.)
33. Corbula carolinensis Conrad (Tp. Eb.)
34. Gyrodes crenata Conrad

In the Chattahoochee region, 14 of the 34 species in the list, marked (Rc), range up into the overlying *Exogyra costata* zone; 20, marked (Tp), occur in the underlying Tombigbee member of the Eutaw formation; 7, marked (Eb), occur in the basal beds of the Eutaw formation, and 10 are restricted to the beds in question.

The 14 species in the list which range up into the zone of *Exogyra costata* are eliminated from further consideration on account of their wide vertical range. The table given below shows the ranges of the remaining 20 both within and without the Chattahoochee region:

Table showing ranges of species which in the Chattahoochee region occur in that part of the Ripley formation included within the Exogyra ponderosa zone exclusive of those which range upward into the Exogyra costata zone.

	Basal beds of Eutaw formation in Chattahoochee region.	Tombigbee sand member of Eutaw formation in Chattahoochee region.	Tombigbee sand member (*Mortoniceras* sub-zone) west of Chattahoochee region in Alabama and east-central Mississippi.	Part of *Exogyra ponderosa* zone above the *Mortoniceras* sub-zone west of Chattahoochee region in Alabama and Mississippi.	*Exogyra costata* zone west of Chattahoochee region in Alabama and Mississippi.	Black Creek formation of the Carolinas.	Peedee sand of the Carolinas (=*Exogyra costata* zone).	Magothy formation of New Jersey.	Matawan group of New Jersey.
1. Cucullaea carolinensis (Gabb)		x		x[3]		x			
2. Trigonoarca sp. nov. (Roods Bend, etc.)						x			
3. Nemodon brevifrons Conrad		x		x		x		x	x[1]
4. Barbatia lintea Conrad					x	x			
5. Ostrea sp. nov. (large, Roods Bend, etc.)			x?			x			
6. Exogyra ponderosa var. erraticostata Stephenson		x	x	x		x	x		
7. Trigonia sp. nov. (Same as sp. nov. from Snow Hill, N. C.)						x			
8. Pecten burlingtonensis Gabb		x		x					x[2]
9. Pecten sp. nov. (same as sp. nov. from Snow Hill, N. C.)	x	x	x			x			
10. Anomia lintea Conrad						x	x		
11. Anomia sp. nov. (same as sp. nov. from Snow Hill N. C.)	x	x	x	x		x			
12. Crassatellites carolinensis Conrad		x[7]?	x	x[7]?		x			
13. Crassatellites sp. nov. (Roods Bend, etc.)				x		x			x[3]
14. Lucina glebula Conrad		x	x[7]?	x[7]?		x		x	x[4]
15. Isocardia cliffwoodensis Weller				x		x			
16. Aphrodina regia Conrad				x		x			
17. Cyclothyris alta Conrad		x	x	x		x			x[5]
18. Baroda carolinensis Conrad				x		x		x	x[6]
19. Corbula carolinensis Conrad	x	x	x	x		x			
20. Gyrodes crenata Conrad			x		x	x			

Note.—See footnotes on page 207.

Of the 20 species restricted below the zone of *Exogyra ponderosa* in the Chattahoochee region, 10 (one questionably, see foot-note 7 in the table) range down into the underlying Tombigbee sand member of the Eutaw formation. Eight of the species (two questionably, see foot-note 7 in the table) occur in the *Mortoniceras* sub-zone of the Tombigbee sand in the region to the west of the Chattahoochee region in Alabama and Mississippi. Thirteen (four questionably, see foot-note 7 in the table) occur in that part of the zone of *Exogyra ponderosa* above the *Mortoniceras* sub-zone in the same region; and two occur in the *Exogyra costata* zone in northern Mississippi.

In the Carolina region all but one of the 20 species occur in the Black Creek formation, and one (or questionably two) ranges up into the overlying Peedee sand.

In New Jersey three of the 20 species occur in the Magothy formation and five (two questionably, see foot-notes 3 and 5 in the table) occur in the Matawan groups. The Merchantville clay-marl which forms the basal portion of the Matawan group is believed to correspond approximately to the Tombigbee sand member of the Eutaw formation (see pp. 145-149 of this report), which underlies that portion of the Chattahoochee section now being considered. By referring to the foot-notes in the table it will be seen that all of the five species occurring in the Matawan groups are present in beds above the Merchantville clay-marl, but that three of the five also range down into the Merchantville beds.

Of the 20 restricted species given in the table only three are known to range above the zone of *Exogyra ponderosa* into the zone of *Exogyra costata* anywhere in the Atlantic coast and eastern Gulf regions.

The conclusions reached regarding the age and stratigraphic relations of the beds under consideration may be summed up as follows:

In the Chattahoochee region these beds fill in the gap between the underlying *Mortoniceras* sub-zone of the Tombigbee sand and the base of the overlying *Exogyra costata* zone. These two delimiting horizons are traceable throughout the greater extent of the eastern Gulf Upper Cretaceous, and by this means the equivalents of the

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[1]Occurs in Wenonah sand of Matawan group.

[2]Occurs in Merchantville clay-marl, Woodbury clay, and Wenonah sand of Matawan group.

[3]Probably same as *Lucina cretacea* Whitfield from the Woodbury clay of the Matawan group.

[4]Occurs in the Woodbury clay and Wenonah sand of the Matawan group.

[5]Probably same as *Corbula bisulcata* Conrad which occurs in the Magothy formation and in the Merchantville clay-marl and the Woodbury clay of the Matawan group.

[6]Occurs in the Merchantville clay marl, Woodbury clay, and Wenonah sand of the Matawan group.

[7]The questionably identified species *Crassatellites carolinensis* Conrad and *Lucina glebula* Conrad, although not confidently referred to these species belong to types of the genus not known to occur above the zone of *Exogyra ponderosa*.

beds are fixed for practically the whole of the region. The contained fauna as developed in the Chattahoochee region is traceable westward between these limits into Alabama as far as the central part of Bullock County, being well developed in the vicinity of Union Springs. In Bullock County the beds merge horizontally into the strata forming the lower half of the Selma chalk. The conditions under which the chalk beds were laid down appear to have been unfavorable for the existence or for the preservation of many of the species characterizing the fauna in the Chattahoochee region, for in the chalk the fauna is poorly represented; however, many of the forms reappear again in non-chalky representatives of the same beds in northern Mississippi.

The evidence for correlating the beds in question with the invertebrate-bearing beds of the Black Creek formation of the Carolinas is very strong; for of the 20 species restricted below the zone of *Exogyra costata* in the Chattahoochee region 19 occur in the Black Creek formation, and only one (or questionably two) of the 19 is known in the overlying Peedee beds.

Six of the 20 species (two questionably) occur in the Matawan group of New Jersey and none of the six are known in the overlying Monmouth formation. The evidence is satisfactory therefore for regarding the Chattahoochee beds under consideration as corresponding to the Matawan group exclusive, however, of the Merchantville clay-marl which forms the base of the Matawan. For reasons given in a preceding chapter (p. 149) the Merchantville beds are considered the equivalents of the underlying Tombigbee sand member of the Eutaw formation.

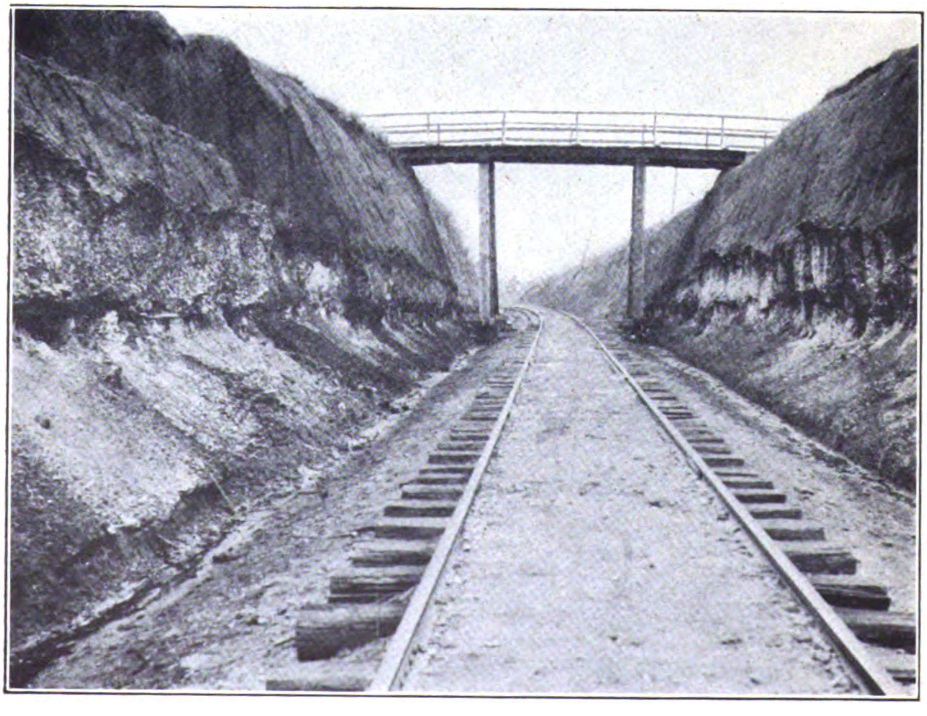
The remains of a few vertebrate animals, consisting of teeth and fragments of bones, have been found in the formation. The forms thus far identified are given in the list below:

Pisces:
- Corax falcatus Agassiz
- Lamna texana Roemer
- Otodus sp.
- Ischyrhiza mira Leidy (Identified by J. W. Gidley)

Reptilia: (Identified by C. W. Gilmore.)
- Fragments of the turtle Taphrosphys
- Fragment of large dinosaur limb bone
- Vertebra of mososauroid reptile
- Thecachampsa rugosa Emmons (vertebra)
- Polydectes biturgidus Cope (teeth)

The sharks, *Corax falcatus* Agassiz and *Lamna texana* Roemer, are wide ranging forms, both geographically and stratigraphically, and have no value in correlation. Of the sphyræoid, *Ischyrhiza mira* Leidy, Mr. Gidley says: "This species is abundant in the

A. GULLY 10½ MILES NORTHEAST OF GEORGETOWN, SHOWING COARSE, UNCONSOLIDATED SANDS OF THE PROVIDENCE SAND MEMBER OF THE RIPLEY FORMATION.



B. CUT OF C. OF GA. RY., ONE MILE SOUTHEAST OF BUENA VISTA, SHOWING UNCONFORMABLE CONTACT BETWEEN PROVIDENCE SAND MEMBER OF THE RIPLEY AND OVERLYING EOCENE.

green sand formations of the eastern and southeastern United States coast, and ranges in time through the Tertiary period."

The two crocodilian species, *Thecachampsa rugosa* Emmons, and *Polydectes biturgidis* Cope, have also been identified by Mr. Gilmore from Phoebus Landing, Cape Fear River, N. C., an upper Black Creek horizon. This evidence is therefore corroborative of that afforded by the fossil invertebrates.

Too little is known of the range of the remainder of the forms listed to render them of value in correlation.

Fossil plants have been found in the Cusseta member of the Ripley formation at two localities; one, six miles northeast of Buena Vista, in Marion County, and the other near Byron, in Houston County. E. W. Berry, to whom the plants were submitted, recognized from the first named locality six species. Concerning these he says: (Quoted from an unpublished manuscript.)

"Three of the foregoing occur in the underlying Eutaw beds and all but the *Ficus*, which is new, are found in the Black Creek beds of North and South Carolina. The *Andromeda*, *Araucaria*, and *Doryanthophyllum*, occur in the Tuscaloosa formation, but are confined, so far as known, to the so-called upper Tuscaloosa beds near Havana in Hale County, Ala., although it is probable that the former will be identified from earlier horizons in Tuscaloosa. They are all, moreover, especially characteristic species of the Black Creek beds, and the *Andromeda* is one of the type fossils of the Magothy formation of the northern Coastal Plain, although it makes its earliest appearance in the Raritan formation, as does also the *Eucalyptus*. * * *

Concerning those from Byron, he says:

"These plants number but three species: *Dryopteris* sp. nov. Berry, *Cunninghamites* elegans (Corda) Endl., and *Araucaria jeffreyi* Berry, the former being new to science. Since the genus *Dryopteris* ranges from the Lower Cretaceous to the Recent and the Georgia species are not closely allied to any described form, it has no value in correlation. Of the other two forms, *Cunninghamites elegans* has a rather wide goegraphical range occurring both in this country and abroad. Its geological range is also considerable. In Europe it ranges from the Cenomanien to the Senonian inclusive, and in this country it has a parallel range from the Magothy flora of the east to the Montana flora of the west. It has been recorded from Lower Cretaceous horizons in Europe but the latter determinations are believed to be erroneous. The nearest geographical occurrence to that in Georgia is that of the upper Black Creek beds of North Carolina, hence the conclusion that the exposures near Byron are not older than those of the Magothy or the Black Creek beds appears to be firmly established.

"The remaining species, *Araucaria jeffreyi*, is not a widespread form, but its intimate association, in the Eutaw formation at Chimney Bluff, Ga., and in the Black Creek formation of North Carolina, with *Araucaria bladenensis*, renders it extremely probably that the former represents the cone scales of a species of which the latter represents the foliage. Taken alone, *Araucaria jeffreyi* points to the same conclusions regarding the age of the deposits at Byron, as does the distribution of *Araucaria bladenensis*. but since the latter furnishes more definite data it will be briefly considered.

"*Araucaria bladenensis* is one of the most abundant and typical forms of the Black Creek beds in North and South Carolina, ranging from their base to their summit. It has also been found in the Cusseta member near

Buena Vista, at the top of the Eutaw formation at Chimney Bluff, and at the top of the Tuscaloosa, or in the base of the Eutaw of Smith in western Alabama, while a closely allied form occurs in the Magothy of New Jersey."

The evidence afforded by the fossil plants is in harmony, therefore, with that afforded by the fossil invertebrates so far as the correlation of the strata containing them with the Black Creek formation of the Carolinas is concerned. As regards the New Jersey Cretaceous, however, Berry apparently regards the beds as corresponding to a somewhat earlier horizon than that indicated by the invertebrates—namely, to the Magothy formation. However, in an unpublished manuscript on the Upper Cretaceous flora of South Carolina he admits the possibility of the Magothy flora having persisted to a later time in the Carolinas and Georgia than in New Jersey.

Exogyra costata zone.—In the Chattahoochee region the following species, 103 in number, have been identified from the *Exogyra costata* zone of the Ripley formation:

Cassidulus porrectus Clark
Cassidulus subconicus Clark
Cassidulus conoideus Clark
Cassidulus micrococcus Slocum
Cassidulus subquadratus Conrad
Hemiaster ungula (Morton)
Hemiaster lacunosus Slocum
? Coptostoma mortoni (de Loriol)
Serpula cretacea (Conrad)
Serpula barbata Morton
Serpula sp. (nearly straight tube) (Tp.)
Hamulus onyx Morton (Rp. Tp.
Hamulus squamosus Gabb
Nucula percrassa Conrad (Rp. Tp. Eb.)
Nucula cuneifrons Conrad
Nucula eufalensis Gabb (Tp.)
Leda pinnaforma Gabb
Leda longifrons Conrad (Tp.)
Perrisonota protexta Conrad (Tp.)
Cucullaea vulgaris Morton
Cucullaea littlei Gabb
Cucullaea antrosa Morton
Breviarca cuneata Gabb
Nemodon eufalensis Conrad
Lima reticulata Forbes (Tp.)
Lima acutilineata (Conrad)
Lima pelagica Morton
Anomia argentaria Morton (Rp. Tp.)
Anomia linifera Conrad
Anomia sp. nov. (Pataula Creek, etc.)
Paranomia scabra (Morton)
Pulvinites argentea Conrad
Crenella serica Conrad
Dreissensia tippana Conrad
Pholadomya occidentalis Morton
Pholadomya sp. nov. (Pataula Creek, etc.)
Anatimya anteradiata Conrad
Cymella bella Conrad (Tp.)
Liopistha protexta Conrad
Cuspidaria ventricosa Meek & Hayden
Veniella conradi (Morton) (Rp. Tp.)
Etea carolinensis Conrad (Tp. Eb.)
Vetericardia crenalirata (Conrad) (Tp.)
Crassatellites pteropsis Conrad
Crassatellites eufalensis Gabb
Scambula perplana Conrad
Tenea pinguis (Conrad)
Sphaerella concentrica Conrad

Glycymeris subaustralis (d'Orbigny)
Gervilliopsis ensiformis Conrad (Tp.)
Ostrea subspatulata Forbes
Ostrea plumosa Morton (Rp. Tp.)
Ostrea tecticosta Gabb (Rp.)
Ostrea larva Lamarck
Ostrea peculiaris Conrad
Gryphaea vesicularis Lamarck (Rp.)
Exogyra costata Say
Exogyra costata var. cancellata Stephenson
Trigonia eufalensis Gabb (Tp.)
Trigonia angulicostata Gabb
Pecten quinquecostatus Sowerby (Tp.)
Pecten argillensis Conrad
Pecten simplicius Conrad (Tp.)
Pecten tenuitestus Gabb
Pecten quinquenarius Conrad (Rp.)
Panopea decisa Conrad
Gastrochaena americana Gabb
Dentalium ripleyanum Gabb (Tp.)
Cadulus obnutus (Conrad) (Tp.)
Scala sillimani (Morton)
Lunatia obliquata Meek & Hayden (Tp.)
Turritella vertebroides Morton
Turritella trilira Conrad (Tp.)
Turritella sp. nov. (two spiral ridges)
Pterocerella tippana Conrad
Pugnellus densatus Conrad
Cardium eufaulense Conrad (Rp. Tp.)
Cardium spillmani Conrad (Tp.)
Cardium kümmeli Weller
Cardium tippanum Conrad
Cardium alabamense Gabb (Tp.)
Cyprimeria depressa Conrad
Cyprimeria alta Conrad (Rp. Tp. Eb.)
Cyprimeria densata (Conrad) (Rp.)
Aphrodina tippana (Conrad)
Aenona eufalensis Conrad
Legumen planulatum (Conrad) (Rp. Tp.)
Linearia metastriata Conrad (Tp.)
Leptosolen biplicata Conrad (Rp. Tp. Eb.)
Cymbophora lintea (Conrad) (Rp. Tp. Eb.)
Corbula crassiplica Gabb (Tp.)
Strepsidura interrupta Conrad
Rapana stantoni Weller
Volutomorpha dumansensis Dall
Morea cancellaria Conrad
Pleurotoma ? melanopsis (Conrad)
Pleurotoma ? laqueata (Conrad)
Ringicula pulchella Shumard
Cylichna recta Morton
Nautilus dekayi Morton
Sphenodiscus pleuriseptus (Conrad)
Hamites sp. nov. (same as from Prairie Bluff, etc.)
Turrilites alternatus Tuomey

Of the 103 species listed, 14, marked (Rp), range down into that part of the *Exogyra ponderosa* zone forming the lower part of the Ripley formation; 30, marked (Tp), occur in the Tombigbee sand member of the Eutaw formation; five, marked (Eb), occur in the basal beds of the Eutaw formation, and 69 are restricted to the *Exogyra costata* zone.

The ranges of the 69 restricted species elsewhere in the eastern Gulf region and in the Carolinas and New Jersey are given in the following table.

Table showing ranges of species outside the Chattahoochee region which in that region are restricted to the zone of Exogyra costata.

	Tombigbee sand member (*Mortoniceras* sub-zone) west of Chattahoochee region in Alabama and east-central Mississippi.	Part of *Exogyra ponderosa* zone above the *Mortoniceras* sub-zone west of Chattahoochee region in Alabama and Mississippi.	*Exogyra costata* zone west of Chattahoochee region in Alabama and Mississippi.	Black Creek formation of the Carolinas.	Peedee sand of the Carolinas (=*Exogyra costata* zone).	Magothy formation of New Jersey.	Matawan group New Jersey.	Monmouth formation of New Jersey (=*Exogyra costata* zone).	Rancocas formation of New Jersey.
1. Cassidulus porrectus Clark*									
2. Cassidulus subconicus Clark*									
3. Cassidulus conideus Clark*									
4. Cassidulus micrococcus Slocum*									
5. Cassidulus subquadratus Conrad	x	x	x						
6. Hemiaster ungula (Morton)*			x						x
7. Hemiaster lacunosus Slocum*			x						
8. ? Coptostoma mortoni (de Loriol)*									
9. Serpula cretacea (Conrad)		x	x	x	x				
10. Serpula barbata Morton*									
11. Hamulus squamosus Gabb	x	x	x	x					
12. Nucula cuneifrons Conrad*			x						
13. Leda pinnaforma Gabb		x	x				x		
14. Cucullaea vulgaris Morton*			x					x	
15. Cucullaea littlei Gabb*								x	
16. Cucullaea antrosa Morton			x	x	x		x	x	
17. Breviarca cuneata Gabb			x				x?		
18. Nemodon eufalensis Conrad			x	x			x	x	
19. Glycymeris subaustralis (d'Orbigny)		x	x	x			x	x	
20. Ostrea subspatulata Forbes*			x		x		x[1]?		
21. Ostrea larva Lamarck		x	x		x		x	x	
22. Ostrea peculiaris Conrad*			x						
23. Exogyra costata Say*			x		x			x	
24. Exogyra costata var. cancellata Stephenson*			x		x				
25. Trigonia angulicostata Gabb*			x						
26. Pecten argillensis Conrad			x				x	x	
27. Pecten tenuitestus Gabb*			x		x			x	
28. Lima acutilineata (Conrad)*			x		x				
29. Lima pelagica Morton		x?		x	x			x	
30. Anomia linifera Conrad				x					
31. Anomia sp. nov. (Pataula Creek, etc.)*			x		x?				
32. Paranomia scabra (Morton)		x	x		x		x	x	
33. Pulvinites argentea Conrad*			x						
34. Crenella serica Conrad			x		x		x	x	

	Tombigbee sand member (*Mortoniceras* sub-zone) west of Chattahoochee region in Alabama and east-central Mississippi.	Part of *Exogyra ponderosa* zone above the *Mortoniceras* sub-zone west Chattahoochee region in Alabama and Mississippi.	*Exogyra costata* zone west of Chattahoochee region in Alabama and Mississippi.	Black Creek formation of the Carolinas.	Peedee sand of the Carolinas (=*Exogyra costata* zone).	Magothy formation of New Jersey.	Matawan group of New Jersey.	Monmouth formation of New Jersey (=*Exogyra costata* zone.)	Rancocas formation of New Jersey.
35. Dreissensia tippana Conrad* . . .			x						
36. Pholadomya occidentalis Morton . .			x			x	x		
37. Pholadomya sp. nov. (Pataula Creek, etc.)*					x				
38. Anatimya anteradiata Conrad . . .			x				x		
39. Liopistha protexta Conrad			x		x		x[1]?	x	
40. Cuspidaria ventricosa Meek & Hayden			x				x	x	
41. Crassatellites pteropsis Conrad . .			x	x					
42. Crassatellites eufalensis Gabb* . .			x						
43. Scambula perplana Conrad	x	x	x				x		
44. Tenea pinguis (Conrad)	x		x					x	
45. Sphaerella concentrica Conrad* . .			x						
46. Cardium kümmeli Weller*			x					x	
47. Cardium tippanum Conrad*			x						
48. Cyprimeria alta Conrad		x	x						
49. Aphrodina tippana (Conrad) . . .			x			x	x		
50. Aenona eufalensis Conrad			x				x		
51. Panopea decisa Conrad		x	x		x		x	x	
52. Gastrochaena americana Gabb . . .		x	x	x					x
53. Scala sillimani (Morton)			x				x	x	
54. Turritella vertebroides Morton* . .			x		x			x	
55. Turritella sp. nov. (two spiral ridges*)			x				x[1]		
56. Pterocerella tippana Conrad			x		x		x?		
57. Pugnellus densatus Conrad			x						
58. Strepsidura interrupta Conrad* . . .			x						
59. Rapana stantoni Weller								x	
60. Volutomorpha dumasensis Dall* . .			x						
61. Morea cancellaria Conrad*			x						
62. Pleurotoma ? melanopsis (Conrad) .			x						
63. Pleurotoma ? laqueata (Conrad) *			x						
64. Ringicula pulchella Shumard* . . .			x						
65. Cylichna recta Gabb			x				x[1]	x	
66. Nautilus dekayi Morton*			x		x			x	
67. Sphenodiscus pleuriseptus (Conrad)*			x						
68. Hamites sp. nov. (same as from Prairie Bluff, etc.)*			x						
69. Turrilites alternatus Tuomey * . .			x						

[1]Occur only in the Wenonah sand which forms the uppermost formation of the Matawan group. The form from the Wenonah sand referred to *Ostrea subspatulata* Forbes is probably incorrectly identified.

In the eastern Gulf region to the west of the Chattahoochee region, three of the 69 restricted species occur in the Tombigbee sand member (*Mortoniceras* sub-zone) of the Eutaw formation; 12 (one questionably) occur in that part of the *Exogyra ponderosa* zone which lies above the *Mortoniceras* sub-zone; and 58 occur in the zone of *Exogyra costata.*

The Peedee sand (*Exogyra costata* zone) of the Carolinas has furnished a small fauna as compared with that of the zone of *Exogyra costata* in the eastern Gulf region—the total number of species known being 28. Of the 69 species given in the above list 18 occur in the Peedee sand, and nine occur in the underlying Black Creek formation. Of the 18 species common to the *Exogyra costata zone* of the two regions at least nine are characteristic species of that zone. In New Jersey two of the 69 species occur in the Magothy formation; 22 (four questionably) in the Matawan group; 21 in the Monmouth formation, and two in the Rancocas formation. Of the 21 species common to the Monmouth formation at least seven are regarded as characteristic of the zone of *Exogyra costata.* The comparison with New Jersey is made on the basis of the distribution of species as given by Dr. Stuart Weller.[1] The percentage of the 69 species common to the Matawan group which is below the zone of *Exogyra costata* is rather larger than would be expected. However, four of the species are reported only from the Wenonah sand, which forms the uppermost formation of the Matawan group, and it is probable that several of the species are incorrectly identified since obviously many of the specimens upon which the identifications are based are poorly preserved.

Of the 69 species restricted to the zone of *Exogyra costata* in the Chattahoochee region, 38, marked in the table with asterisks, are not known to occur in beds lower than that zone anywhere in the eastern Gulf or Atlantic Coastal Plain. Of the 38 restricted species, 30 occur in the zone of *Exogyra costata* to the west of the Chattahoochee region in Alabama or Mississippi; nine (one questionably) in the Peedee sand of the Carolinas, and seven in the Monmouth formation of New Jersey.

From the distribution of species as given on preceding pages the following conclusions have been deduced:

The *Exogyra costata* zone of the Chattahoochee region is the Chattahoochee representative of a paleontologic zone which in western Alabama and east-central Mississippi is represented by approximately the upper one-half of the Selma chalk, and in northern Mississippi is represented by the Ripley formation and by a part

[1]Geol. Survey of New Jersey. Vol. 4, Paleontologic series, text and plates. 1907.

of the underlying Selma chalk. In the Carolinas this zone is represented by the Peėdee sand, and in New Jersey by the Monmouth formation. A diagrammatic representation of these equivalencies is given in Plate V.

The vertebrate remains thus far found in the zone of *Exogyra costata* in the Chattahoochee region include the following:

Pisces:

Corax falcatus Agassiz
Lamna texana Roemer
Otodus sp. ?
Ischyrhiza mira Leidy

Reptilia:

Tooth of mososauroid reptile
Dermal scutes, probably of the preceding form.

Corax falcatus Agassiz, *Lamna texana* Roemer, and *Ischyrhiza mira* Leidy are species of wide geographic and stratigraphic range and are valueless in correlation. The ranges of the remaining forms are not known and consequently they throw no light on the age relationships of the deposits.

With the exception of occasional pieces of lignite, fossil plants have been found at but one place in the beds under consideration. A few imperfect leaf remains were collected near the base of the zone of *Exogyra costata* on Cowikee Creek, a few hundred yards above its junction with Chattahoochee River in Barbour County, Ala. E. W. Berry, who collected and studied these specimens, in a letter to the writer says:

"The fossil plants from Cowikee Creek are few in number and poorly preserved. The following forms are represented:

Bauhinia sp. nov.	Salix sp.
Platanus sp. nov.	Sapindus sp.
Laurus sp.	Fern, not determinable

"The remains of the *Bauhinia* and *Platinus* are complete enough to demonstrate that they are new, the balance are too poor for accurate determination, although they all appear to be distinct from any forms of the earlier Eastern Cretaceous floras."

The slight evidence afforded by these plant remains seems to indicate that a change in the Cretaceous flora of the region took place approximately coincident with the inauguration of the fauna characterizing the zone of *Exogyra costata*.

TERTIARY AND QUATERNARY

BY OTTO VEATCH AND LLOYD WILLIAM STEPHENSON

EOCENE

MIDWAY FORMATION

NAME

The Midway formation comprises the basal Eocene of the Georgia Coastal Plain. The term Midway was first used by Dr. E. A. Smith[1] and L. C. Johnson to apply to a formation on the Alabama River in Wilcox County, Alabama. From this locality, it has been traced eastward to the Chattahoochee River, and the strata described by D. W. Langdon[2] under the name Midway series (Clayton division). The Midway group of Alabama comprises the Clayton limestone, the Sucarnochee clay, and Naheola formation ("Matthews Landing"); the two latter were not originally included in the Midway group. The upper part of the Midway group of Alabama is apparently missing on Chattahoochee River as the Wilcox formation there rests on the eroded upper surface of Midway strata. The term Midway has received general recognition as a permanent stratigraphic name in the literature on the Coastal Plain geology of Alabama, Mississippi, and Louisiana.

Dr. J. W. Spencer[3] published some notes on the formation in Georgia and described sections along Flint River. Brief descriptions of a general nature have also been written by McCallie[4] and Veatch.[5]

DEFINITION

Stratigraphic relations.—The Midway formation rests unconformably upon the Upper Cretaceous. Irregular contacts that appear to represent erosion unconformities between the two divisions were noted, especially in the gullies north and west of Lumpkin, Stewart County. The strata of the basal Midway and the Upper Cretaceous seem to be lithologically similar and on account of inadequate exposures considerable difficulty is experienced in determining the exact location and nature of the contact.

A probable contact between the Cretaceous and the Eocene is exposed in the first railroad cut east of the depot at Lumpkin, where

[1] Bull. U. S. Geol. Surv. No. 43, 1887, p. 62.
[2] Ala. Geol. Surv. Rept. on the Geology of the Coastal Plain. 1894. pages 418 to 743.
[3] Geol. Surv. of Georgia. First Report of Progress. 1890-91. pp. 43-49.
[4] Geol. Survey of Georgia. Bull. No. 15. Underground Waters of Georgia, 1908, pp. 34-35.
[5] Geological Survey of Georgia, Bull. No. 18. Clay Deposits of Georgia, 1909, pp. 79-82.

the base of the Eocene consists of four to six feet of iron stained clay containing ferruginous sandy layers bearing poorly preserved fossils, resting upon light colored sandy clay of probable Cretaceous age. There is only slight evidence of an unconformity, however. A probable uncomformity was also noted about one and a half miles south of Lumpkin on the Cuthbert public road. Here a ferruginous sand is separated from a kaolinic sand by a line of pebbles and what seems to be certainly Eocene strata appears a short distance to the southward.

In Marion, Schley, and Macon counties the Midway formation lies in contact with the Upper Cretaceous which it closely resembles in lithologic character, but in mapping it is not possible to draw a sharp line between the two. It consists mainly of unconsolidated red, purplish and white sands in which thin, siliceous limonitic layers and crusts and highly ferruginous sandstone are common. Thin beds of impure clays also occur, but neither the clays nor the ferruginous sandstone contain well preserved fossils.

A probable contact between the Upper Cretaceous and the Midway formation occurs in a cut of the Central of Georgia Railway, one mile east of Buena Vista. The two divisions are separated by thin limonitic layers imbedded in a stained clay. The lower part of the section is white or light colored sand and sandy clay, the upper part, probably representing the Eocene, is a bright red ferruginous sand.

At Underwood Ferry, on Flint River, six miles southwest of Marshallville, Macon County, the base of the bluff consists of gray or yellow rather compact argillaceous sand which contains poorly preserved fossils. From this locality a specimen of *Venericardia planicosta* was obtained and on the basis of this fossil the strata are classed as Eocene. This is evidently near the northern margin of the Eocene, but the relations to the Cretaceous in this vicinity are obscure. It is also not positively known whether the Eocene represents the Midway or Wilcox.

A gray and black, laminated, sandy clay bearing *Venericardia planicosta* was also discovered at Barrow's Mill in Houston County, five miles east of Marshallville. There is here a poorly exposed unconformity which may represent a Cretaceous-Eocene contact. *Venericardia planicosta* and *Turritella humerosa* were obtained in a similar sandy clay on Robert Slappy's land, four miles east of Marshallville, The fossils are inadequate for determining whether the exposure is Midway or Wilcox.

No good physical evidence of an unconformity representing a considerable time interval between the Cretaceous and Midway has yet

been discovered in Georgia, but there is paleontologic evidence that this interval is as great here as in adjoining states.

The Midway is separated at Fort Gaines from the overlying Wilcox by a remarkable unconformity, which will be subsequently described. Superficial gray and brownish sand is spread over the formation in places and Pleistocene terrace deposits overlie it along Chattahoochee and Flint rivers.

Lithologic characters.—The Midway is mainly a marine formation and consists of sands, clays, marls, and limestones. Much of the sand, however, has a fresh water aspect. The lower part of the formation consists principally of sands and clays and the upper part consists of marls, clays, and limestones, but there is such variety in the character of the sediments that sharp lines of divisions based upon lithology can not be drawn. Thin layers of flint interbedded with sands and clays were noted in the lower part. The sands are vari-colored, generally friable, and in several places contain lenticular, massive layers of white clay. In the lower part of the formation limonite is rather widely distributed in the sands in the form of thin crusts and as hollow concretions having black, polished, and botryoidal interiors. The limestones are fossiliferous, usually very hard and generally highly arenaceous, but in a few places sufficiently pure for use in the manufacture of lime. Friable marl, made up of glauconite, quartz sand, clay, and shells, occurs, and also laminated, black clay, and fullers earth. The limestones are conspicuous at several localities and are more abundantly fossiliferous than other parts of the formation. Individual beds of limestone in natural exposures are thin, from two or three to 25 feet in thickness, and are interbedded with clays, marls, and sands. Sands and clays make up by far the greater part of the deposits; the lithologic character and the character of the fossils indicate a very shallow water deposition for the whole formation.

Thickness.—The thickness of the Midway (referred by Langdon to the Clayton division of the Midway group, as used in Alabama) on Chattahoochee River was estimated by Langdon[1] at 218 feet. The width of the outcrop on the Chattahoochee is about eight miles and it is believed that Langdon's estimate is nearly correct, but it is probably excessive rather than too small. The thickness of the whole Midway northeastward is probably greater, and while it can not be accurately estimated, is about 300 to 400 feet. The width of the outcrop on Flint River is about 15 miles and it is not believed that an estimate of 400 feet is excessive. As recorded dips of strata are variable, individual beds not continuous, and only a few well data available, no accurate estimate is possible.

[1]Langdon, D. W., Geology of the Coastal Plain: Geol. Survey Alabama, 1894, p. 369.

Paleontologic characters.—The collections of fossils from the formation are on the whole rather meager. This is due to a paucity of fossils in the formation rather than to insufficient field work, since all of the best known exposures have been visited. *Ostrea crenulimarginata* seems to be a characteristic fossil and is found at nearly every limestone and marl outcrop. The basal part, which consists mainly of sands and clay, is very poor in fossils. *Venericardia planicosta, Turritella,* and other forms occur, but these are common to other Eocene formations. One of the characteristic fossils of the formation in Alabama, *Enclimatoceras ulrichi,* has not thus far been found in Georgia. The following is a complete list of the forms which have been identified.

Fossils from the Midway Formation in Georgia.

Turritella mortoni Conrad
Turritella humerosa Conrad
Mesalia alabamiensis (Whitfield)
Arca sp.
Ostrea crenulimarginata Gabb
Ostrea pulaskensis Harris
Lithodomus gainesensis Harris
Crassatellites
Venericardia planicosta Lamarck
Venericardia smithii Aldrich
Cardium sp.
Protocardia sp.
Cytherea ripleyana (Gabb)

The determinations are by Dr. Vaughan from collections made by Veatch, McCallie, and Stephenson.

A fossil turtle, *Agomphus oxysternum,* has been found in the Midway near Montezuma. The specimen was first described by Cope[1] and later by Hay.[2]

Areal distribution.—The Midway occurs in a narrow belt, having a northeast southwest trend, extending from Fort Gaines on Chattahoochee River to Montezuma on Flint River and thence a short distance into Houston County. On the Chattahoochee it reaches a width of about eight miles and on the Flint a width of about 15 miles, while between the two rivers the belt has an average width of eight to ten miles. It is the surface formation over much of Clay, Quitman, Stewart, Randolph, Marion, Schley, Webster, and Macon counties. It extends eastward from Flint River into Houston County, probably as far as Myrtle on the Perry branch of the Central of Georgia Railway. No occurrence is known east of the Ocmulgee River. In this area it is probably overlapped by higher Eocene formations.

Physiographic expression.—The topography of the area underlain by the Midway is broken and hilly, somewhat similar to the Creta-

[1]Proc. Amer. Philos. Soc., Vol. 17, 1877, p. 82.
[2]Hay, O. P., Fossil Turtles of North America: Carnegie Institution, 1908, p. 253.

ceous area to the northward, and in contrast to the level topography of the areas to the southward underlain by Claiborne and Oligocene strata. A few lime-sinks occur in the vicinity of Fort Gaines and north of Cuthbert.

Structure.—The formation presents no notable structural features. It has a low southward dip in conformity with the general southward inclination of all of the older Coastal Plain formations. No data for accurately determining the dip are at hand, on account of the discontinuity of exposures of individual beds. Recorded dips show wide variations due to local disturbances of the strata.

The dip of the formation, as a whole, is roughly estimated at 20 to 30 feet per mile. It is, however, unlikely that this rate of dip is maintained southward under cover of later formations, since Cretáceous fossils, *Anomia argentaria*[1] and *Exogyra costata,* were found in the borings of an artesian well at Albany at 890 and 1,100 feet, respectively, and the base of the Midway according to these fossil determinations might be even above the 890-foot level (for a log of this well see page 317). Local crumpling of clay beds and local very high angles of dip were noted, especially in Stewart, Randolph, and Quitman counties. These may be results of movements which produced the Chattahoochee anticline.

Economic geology.—Limestones and marls of the formation should be of some local value as fertilizers, lime, and road materials. There has been, however, but small utilization of these materials. Localities where they are to be found are mentiond on succeeding pages. The formation contains beds of white fire-clay which may be of some future commercial value. Beds of considerable thickness and extent were found in Quitman, Stewart, Marion, and Macon counties. Limonitic iron ore is widely distributed throughout the lower part of the formation, and at a few places is perhaps of sufficient extent to be of commercial value.

LOCAL DETAILS

Fort Gaines.—Limestone of the Midway formation is prominently exposed in the river bluff at Fort Gaines, and at the old Brown Mill on Comochechebbe Creek, one mile north of the town. Its first known appearance on the Chattahoochee is at a point seven miles above Fort Gaines, near Morris Landing, on the Alabama side of the river. At this locality *Turritella mortoni* is very abundant. There are also *Venericardia planicosta* and other fossils, poorly preserved and not positively identifiable. The material is a greenish, rather

[1]Determinations made by L. W. Stephenson.

calcareous sand. Five miles above Fort Gaines is an exposure of rock, massive-bedded, white, earthy, or chalky in appearance; in texture it is both hard and compact and pulverulent or marly; it contains a high percentage of quartz sand and varies from sandy limestone to a calcareous sand. The limestone at Fort Gaines is poorly fossiliferous; *Ostrea pulaskensis* and *Lithodomus gainesensis* were collected; Bryozoa and small echinoids also occur in it. A maximum of 30 feet of the limestone is exposed in the river bluff at extreme low water. The limestone is best exposed on the Georgia side at the wagon bridge and at a point about 350 yards below the bridge, where a striking unconformity appears between it and the overlying strata. Circular pockets of black, sandy clay occur in the limestone and are probably pot holes, 20 feet or more in depth, which were filled during the deposition of the strata overlying the limestone.

The section exposed at Brown Mill, one mile north of Fort Gaines is as follows:

Section at Brown Mill.

	Feet.
Pleistocene.	
3. **Red and yellow pebbly sand**	**5**
Eocene.	
Wilcox formation.	
2. **Glauconitic sand and friable shell marl**	**6**
(Unconformity.)	
Midway formation.	
1. **Soft, massive-bedded limestone**	**20**

The limestone here is soft, white, massive bedded and sandy, resembling that exposed in the river bluff. The exposures also reveal the sâme remarkable pot-hole unconformities which are present on the river. Fragments of Bryozoa, *O. pulaskensis,* and a small echinoid were collected. The limestone appears in the banks of the creek to about one-half mile above the mill. The continuation of the limestone for at least a short distance northeastward is indicated by lime-sinks. However, the unbroken continuity of this limestone bed northeastward has not been demonstrated. The limestones at Greer Cave, Preston, Quebec, and Montezuma, which are supposed to be equivalent in age to the limestone at Fort Gaines are entirely unlike it in lithologic appearance, and evidence of a limestone bed connecting these localities, which would be afforded by outcrops and the character of the soil, is entirely wanting.

Hatcher.—On the Griffith plantation, four miles south of Hatcher Station, there is an exposure of 20 feet of limestone and marl. This locality is the site of the old Redding mill and lime-kiln. The rock varies from marl through extremely hard, calcareous quartzite to com-

paratively pure compact limestone; it resembles the limestone at Greer Cave and Preston, but differs somewhat in its lithologic appearance from the limestone at Fort Gaines. The rock contains *Ostrea crenulimarginata,* a characteristic fossil of the Midway, and also a smaller species of oyster, probably *O. pulaskensis.* The area of natural exposures is small and attempts to locate outcrops between this locality and Greer Cave in Randolph County were unsuccessful. The overlying stratum is red, argillaceous sand.

The exposures in the Central of Georgia Railway cuts northwest of Hatcher, Quitman County, generally show variegated sand, coarse grained, often kaolinic and micaceous, resembling some of the beds of the Lower Cretaceous. The sands contain pockets of white and stained clays associated with limonitic crusts and hollow concretions. At mile-post 139, thin, limonitic crusts, from a few inches to a foot or two thick, contained casts of fossils, *Dendrophyllia, Venericardia planicosta, Venericardia smithii, Cytherea,* which are Eocene fossils, and a specimen of the Cretaceous genus, *Pugnellus.* At this locality there is a mixture of Eocene and Cretaceous forms. It is probable that the crusts were originally glauconitic sand, since grains of glauconite partially altered to limonite still remain. Also, near mile-post 135, there is an exposure showing 30 feet of yellow, brown, and umber colored, stiff clays, mixed with harsh, gritty, or angular sand. The clay layers here are crumpled and disturbed from their original positions. The same general lithologic characters persist eastward to Flint River in the lower part of the formation. The strata exposed south of Lumpkin are mainly crossbedded quartz sands, containing thin white clay layers; brownish, glauconitic clays, fullers earth, and thin beds of flint were also observed.

Beds of flint which are probably Midway, occur near the gin-house of W. W. Greene, one and one-half miles southwest of Georgetown station. These rocks appear to have been derived by silicification from limestone similar to that at Fort Gaines. The rock lies in the escarpment of the second terrace bordering Chattahoochee River. Similar thin beds of flint have been observed near Beatrice, eight miles southwest of Lumpkin; on the Jones plantation, nine miles southeast of Lumpkin; five miles west of Richland; and at Bells Mill near Preston.

Dr. Vaughan has supplied the following notes:

"At several localities at which Mr. Veatch made collections, fossils are so scarce and those obtained are so poorly preserved, that positive stratigraphic determinations are not possible.

"*Ostrea pulaskensis* and the cast of the interior of an *Arca,* probably the same as the unidentified specimen figured by Professor Harris in his monograph on the Midway, were obtained at the base of the bluff at Fort Gaines. This exposure is definitely known to be Midway.

"The imprint of an *Arca*, probably belonging to the same species as the one from the Midway just referred to, and a *Barbatia*, referred by Professor Harris in his monograph on the "Lignitic" to *B. cuculloides* (Conrad), were found on W. W. Greene's plantation, one and one-half miles southwest of Georgetown. A careful comparison with *B. cuculloides* from the Jackson and Vicksburg in the National Museum leads me to the opinion that Professor Harris has probably allowed too much latitude in variation. It can not be determined from the fossils whether the horizon is Midway or Wilcox.

"An oyster, which appears to be *O. pulaskensis* Harris, and specimens representing at least two species of echinoids, were obtained on the Jones plantation, nine miles southeast of Lumpkin. This exposure is probably Midway.

"*Ostrea*, probably *pulaskensis*, and two species of echinoids, one of which is either the same as, or very close to one of the species found on the Jones plantation, were collected at the 105th mile-post of the Seaboard Air Line Railway, five miles west of Richland. The geologic horizon of this exposure is probably Midway.

"In the vicinity of Bells Mills, four and one-half miles northeast of Preston, poorly preserved fossils were obtained at several localities. Among them are *Cardium*, *Venericardia*, *Leda*, probably *pharcida* Dall, and an oyster suggesting *O. thirsae*. If the oyster is really *O. thirsae*, it indicates that the Wilcox overlapped the eroded surface of the Midway. However, the information at present available does not warrant a positive opinion."

Greer Cave locality.—At Greer Cave, nine miles north of Cuthbert, on the upper Lumpkin road, there is an exposure of 30 feet of hard, gray, rather fine-grained, fossiliferous limestone. Most of the rock is comparatively pure, but near the base of the exposure it becomes very sandy and can be properly termed a calcareous quartzite.

An exposure occurs in the public road one mile south of the above locality. The rock here is compact at the base, grading into a gray or light yellow friable shell marl, and gray calcareous sand. A dark red, clayey sand overlies the marl and may be, in part, residual. The height of the hill here is 70 feet, the lower 30 feet being marl and limestone. The formation at this locality contains characteristic Midway fossils, and is one of the most notable lower Eocene exposures.

Preston.—Midway limestone or marl appears at Lime Spring, on the Cole property, on the south side of Kinchafoonee Creek, two miles southeast of Preston. The rock is a hard grayish limestone or indurated, argillaceous marl, overlain by ferruginous sand. About 15 feet is exposed in the hillside which forms the swamp bluff.

The rock is fossiliferous, but good fossil specimens are rather difficult to obtain. Dr. Vaughan has identified the following fossils from this locality:

Fossils from Lime Spring.

Turritella humerosa Conrad	Ostrea crenulimarginata Gabb
Mesalia alabamiensis (Whitfield)	Protocardia sp.
Ostrea pulaskensis Harris?	Crassatellites sp.

At a point one mile south of Preston on the Weston road there is a thin bed of flint from which Dr. Vaughan has identified: *Tur-*

ritella, Ostrea apparently *thirsae* (Gabb), and *Venericardia.* It is very probable that this bed lies beneath the marl on Kinchafoonee Creek and is hence Midway.[1] A marl, that occurs in the bed of the creek at the old Harrell distillery, about one mile farther south, is similar to that at Lime Spring and contains *Ostrea crenulimarginata* (?).

At Bell's Mill, four and a half miles northeast of Preston, Dr. Vaughan has identified, *Ostrea thirsae, Leda pharcida, Dentalium, Cardium, Lucina.* The fossils were collected from thin flint beds. The geographic position of the beds, (four or five miles north of the Midway at Lime Spring on Kinchafonce Creek) their low topographic position, (lower than the higher ridges and hills of this vicinity, with no suggestion of an overlap), are considered evidence that the strata here may belong to the Midway.

Ellaville.—Near the site of old Quebec, eight miles southwest of Ellaville, there is an exposure of 20 feet of highly siliceous limestone and clay with siliceous nodules, overlain by red, highly ferruginous sand and sandstone. The rock here might be properly termed a calcareous grit. Large angular, crystalline quartz grains are imbedded in a white, opaque and enamel-like calcareous matrix. The rock is very hard and compact and the quartz grains fracture rather than fall out when the rock is broken; the compactness is due in part to a cement of amorphous or opaline silica. Oyster shells, *Ostrea crenulimarginata,* were observed. The rock contains a small amount of phosphate in the form of brown grains or pellets.

At Walls Crossing, four and one-half miles northwest of Ellaville, Midway fossils were collected from a thin marl bed. The marl and limestone bed which is about four feet thick is exposed at the head of a small branch about 200 yards northwest of the cotton gin of Mr. C. H. Wall. Dr. Vaughan has identified the following fossils from this locality:

Fossils from Walls Crossing.

Turritella humerosa Conrad	Venericardia smithii Aldrich
Turritella alabamiensis Whitfield	Cytherea ripleyana (Gabb)
Ostrea crenulimarginata Gabb.	

Montezuma.—Good exposures of the Midway formation appear in the bluffs of Flint River above and below Montezuma. The following section appears in the bluff at the wagon bridge one mile northwest of the town:

[1]See note by T. W. Vaughan, p. 222.

Section one mile northwest of Montezuma.

		Feet.
Pleistocene (terrace deposit).		
6.	Red sand with a covering of brown, incoherent superficial sand	
Age ?		
5.	Laminated, drab clay	15 to 20
Eocene.		
Midway formation.		
4.	Compact limestone, variable thickness; contains large oysters	2
3.	Clay, marl and limestone	8
2.	Massive limestone layer, contains *O. crenulimarginata, Cardium, Crassatellites*	5
1.	Bluish, massive bedded clay and coarse gritty argillaceous sand	15

Northward from the bridge, No. 1 reaches a thickness of 25 feet; the lower end of the bluff is not well exposed and fragments of beds Nos. 2 and 3 have fallen to the base. The dip of the strata is southward, and bed No. 5 doubtless dips beneath the river between the upper wagon bridge and the Central of Georgia railroad bridge.

At a locality two and a half miles north, and on the east side of the river, on the De Vaughn plantation, the following section occurs:

Section on De Vaughn plantation.

		Feet.
5.	Red, argillaceous sand capping bluff	
4.	Clay with nodules of limestone, oyster shells abundant; the materials are weathered and not well exposed . . .	8
3.	Compact, gray, sandy limestone, fossils	3
2.	Friable, calcareous, gray, clayey sand	10
1.	Sandy, glauconitic limestone	20

Another section exposing limestone occurs at Dripping Bluff, nine miles south of Oglethorpe. The limestone is compact, bluish-gray, glauconitic and fossiliferous, containing the characteristic Midway oyster, *O. crenulimarginata* and other fossils. Dripping Bluff is on the west side of Flint River and about half way between the mouths of Sweetwater and Camper creeks.

Section at Dripping Bluff.

		Feet.	In.
Pleistocene (terrace deposit)			
12.	Reddish sand poorly exposed	12 to 15	
Eocene.			
Midway formation.		Feet.	In.
11.	Poorly exposed and partly concealed, but probably calcareous clay, containing limestone nodules .	10	
10.	Interbedded, very thin layers of hard, nodular limestone and clay	5	
9.	Clay	1	
8.	Limestone		8
7.	Black clay marl	1	

	Feet.	In.
6. Nodular limestone and black argillaceous sand .	1	
5. Clay marl	2	
4. Limestone		6
3. Black, compact, argillaceous sand	2½	
2. Hard, pitted, sandy and glauconitic limestone; contains fossils, principally large *O. crenulimarginata*	5	
1. Black, argillaceous sand and sandy marl, not exposed except at low water	3	

Bed No. 2 is apparently dipping southward at the rate of about 30 feet per mile.

The following is a section of a bluff one-fourth to one-half mile above Dripping Bluff.

Section one-half mile above Dripping Bluff.

	Feet.
4. Red and crossbedded, rather coarse sand with small quartz pebbles at the base. This material underlies a terrace plain 45 to 50 feet above the river, and is doubtless Pleistocene	12
Midway formation	
3. White and red fine sand, containing clay laminae	7
2. Black, massive, pyritiferous argillaceous sand, yellowish at the top, with thin limonitic crusts . .	10
1. Massive bluish-white, jointed clay	14+

Bed No. 2 contains a few poor fossil prints. No marl or limestone appears; this indicates the variable nature of the Midway deposition. Furthermore, no limestone or even calcareous strata have been observed between this point and the bluff at Montezuma. A clay bed very similar to No. 1 of the preceding section occurs at Copperas Bluff, about three miles farther down-stream.

Section at Copperas Bluff.

	Feet.
Pleistocene (terrace deposit).	
3. Yellow and orange sand, variable thickness, maximum	20
Eocene.	
Midway formation ?	
2. Black, pyritiferous, massive argillaceous sand, contains a few prints of fossils	15
1. Massive, jointed, bluish-white clay, maximum thickness	15

Beds 1 and 2 are almost identical lithologically with Nos. 1 and 2 of the above section.

WILCOX FORMATION

NAME

The Wilcox formation derives its name from Wilcox County, Alabama, where the formation is typically exposed. Strata of this for-

mation were formerly embraced in the "Lignitic Group." Dr. E. W. Hilgard[1] used the term "Lignitic" in Mississippi for all of the strata lying between the Claiborne and the Cretaceous, and included in it come beds belonging to the Claiborne group. Also in early literature[2] the term was applied to all of the formations lying between the "Burhstone" and the Cretaceous of Alabama. Subsequently,[3] however, the calcareous beds at the base of the Tertiary in Alabama were differentiated and given the name Clayton (a division of the Midway). The term "Chickasaw" was later substituted for "Lignitic", excluding the Flatwoods belt of Mississippi, by Dr. Hilgard and Dr. Dall, and by a still later decision of the committee on nomenclature of the U. S. Geological Survey,[4] the name Wilcox was substituted for that portion of Hilgard's "Lignitic", which lies below the Claiborne group and above the Midway.

D. W. Langdon studied strata of the Wilcox on the Chattahoochee River and made the following divisions:

Lignitic: {
Hatchetigbee
Bashi (Woods Bluff)
Tuscahoma (Bell's Landing)
Nanafalia

These divisions can not be discriminated eastward from the Chattahoochee.

In view of the small thickness of the Wilcox at Fort Gaines, and the probable occurrence of strata of the Claiborne group on Chattahoochee River near water-level four miles south of Fort Gaines (see following pages), it is not unlikely that a portion of the strata classed as "Lignitic" by Langdon, belongs to the Claiborne.

DEFINITION

Stratigraphic relations.—In Georgia, the Wilcox formation includes the strata lying between the Midway formation and the Claiborne group. At Fort Gaines on Chattahoochee River, the Wilcox and the Midway are separated by a remarkable erosion unconformity, represented by holes in the white limestone of the Midway formation filled by black sandy clay of the overlying formation. These holes must originally have had a depth of 20 feet or more. Paleontologic and lithologic differences and the erosion unconformity furnish a sufficient basis for the separation of the Midway and Wilcox formations

[1]Hilgard, E. W., Geology and Agriculture of Mississippi, 1860, p. 108.
[2]Smith, E. A., and Johnson, L. C., U. S. Geol. Survey, Bull. 43, p. 38.
[3]Geol. Surv. of Ala., Report on the Geology of the Coastal Plain, 1894, p. 147.
[4]Crider, A. F., Geology and Mineral Resources of Mississippi, U. S. Geol. Survey, Bull. 283, p. 25.

at Fort Gaines. East of this locality, however, the paucity of the fossils, the fact that no unconformity could be discovered, and the unsatisfactory character of the evidence furnished by the lithologic composition of the strata, has rendered the discrimination of the two formations very difficult; therefore, the boundary line as mapped is necessarily tentative.

The contact with the overlying Claiborne group, where this has been observed, is marked by an undulating line of small pebbles or a stratum of coarse sand, but there is no physical evidence of any considerable time interval having elapsed between the deposition of the two. An unconformity marking the contact between the Claiborne group and the Wilcox formation has been noted at the following localities: in the bluff at Fort Gaines, 50 to 55 feet above Chattahoochee River; in a cut of the Central of Georgia Railway two and one-half miles west of Cuthbert; at Hall's Bridge on Kinchafoonee Creek seven miles southwest of Plains; doubtfully in the public road at Blacks Mills five miles north of Plains; and one and one-half miles southeast of Andersonville, on the south side of Sweetwater Creek, about one mile below Hodge's Mill. Unfortunately, the strata are not fossiliferous, except at Fort Gaines, and the evidence that the unconformities are of stratigraphic importance is not entirely conclusive.

Lithologic characters.—On Chattahoochee River, the formation is made up of sandy, glauconitic, shell marl, dark colored, laminated, often lignitic, sandy clay, in places consolidated into mudstone, and usually dark or gray glauconitic and lignitic sand. The laminated clay exposed in the bluff at Fort Gaines can be traced northeastward, having in Randolph County north and west of Cuthbert, the nature of fullers earth, which in places is glanconitic. At Greer Cave, there seems to be a considerable thickness of vari-colored and kaolinic sand between the Wilcox clay and the limestone of the Midway formation. Black and drab laminated, glauconitic clay and sand were observed on Bear Creek northeast of Weston, Webster County. Gray and black argillaceous and glauconitic sand appears at Magnolia Spring, two and one-half miles north of Plains; in the bed of a branch on the old Morgan plantation, six miles northeast of Plains; and at Hall's Bridge on Kinchafoonee Creek, seven miles southwest of Plains. Farther eastward in Schley and Macon counties and in the vicinity of Andersonville, the strata which might be referred to this formation on the basis of geographic position, are mainly red and vari-colored sands with massive beds of white clay, very pure and in the nature of sedimentary kaolin, bearing little resemblance to the strata on Chattahoochee River.

Thickness.—It seems very probable that Langdon's[1] estimate of 402 feet is excessive, in view of the small thickness of Wilcox at Fort Gaines, and from the fact that Dr. Vaughan has determined *Exogyra costata* from the Blakely well at a depth of 500 to 510 feet. (See page 312). The thickness of strata between the McBean and the Midway formations at Fort Gaines does not exceed 75 feet. The maximum thickness at any place over the area of outcrop probably does not exceed 150 or 200 feet. It is difficult to form an accurate estimate of the thickness of the Wilcox formation as is true also of the underlying Midway formation, for east of Chattahoochee River, neither the base nor the top of the formation has been accurately established. There is a natural exposure of the formation revealing an estimated thickness of 100 feet of strata at Peterson Hill, four and a half miles northwest of Cuthbert. The following is the record[2] of a well at Shellman, Randolph County:

Record of well at Shellman.

		Feet.
5.	Red clay	0 to 18
4.	Quicksand	18 to 148
3.	Blue marl	148 to 300
2.	Very hard limestone	300 to 400
1.	Water bearing formation	400 to 410

Assuming the limestone layer No. 2 to be the same as the Midway limestone which is exposed at Greer Cave about 16 miles northwest, the overlying 152 feet of "blue marl" may belong to the Wilcox formation.

There is no positive proof of strata of Wilcox age on Flint River. It may be entirely overlapped by the Claiborne, but assuming that the strata lying between the Midway formation at Dripping Bluff (see page 225) and the McBean or Vicksburg formations is Wilcox, the thickness is perhaps 100 feet.

Paleontologic characters.—The formation is on the whole poorly fossiliferous. The following Georgia forms have been identified by Dr. Vaughan from collections made by the writer east of the Chattahoochee River:

List of fossils from the Wilcox formation in Georgia.

Actaeon
Turritella mortoni Conrad
Turritella praecincta Conrad
Ostrea thirsae (Gabb)
Venericardia planicosta
Cardium

[1]Langdon, D. W., Report on the Geology of the Coastal Plain, Ala. Geol. Survey, 1894, p. 369.
[2]McCallie, S. W., Underground Waters of Georgia, Bull. 15, 1908, p. 156.

Calyptrea aperta (Solander)	Protocardia
Dentalium	Cytherea
Leda pharcida Dall	Cassidulus (?) sp.
Glycymeris	

At a locality five and one-half miles south of Lumpkin the following fossils were obtained:

Fossils from five and one-half miles south of Lumpkin.

Endopachys maclurii (Lea)[1]	Nucula sp.
Pyrula juvenis Whitfield ?	Paracyathus ? sp.
Turritella sp.	Cucullaea macrodonta Whitfield
Leda (apparently pharcida Dall)	Lucina sp.
Cytherea nutalliopsis Heilprin ?	Cytherea sp.

The species *O. thirsae, O. compressirostra, Chlamys greggii,* and *Cucullaea macrodonta* have been identified from beds near Fort Gaines. Dr. Vaughan has also identified a small oyster as *O. thirsae,* a species considered characteristic of the Wilcox formation, from beds four and one-half miles northeast of Preston, and a specimen apparently *O. thirsae* from a flint bed one mile south of Preston. There, is however, a possibility of these beds belonging to the Midway. As the collections are small and the material in general poorly preserved, often stratigraphic deductions from fossils can not be made with the same surety for Georgia as for states to the west where fossils are more abundant and better preserved. Further mention of the material near Preston and a note by Dr. Vaughan will be found on pages 222-223.

Areal distribution.—The Wilcox formation extends in a northeastward direction from the vicinity of Fort Gaines on Chattahoochee River probably to Flint River in the northeastern part of Sumter County. The width of the belt of outcrop is on the average perhaps not more than five or six miles. It is, to some extent, overlapped and obscured by the McBean and Vicksburg formations. The formation has not been recognized east of Flint and Ocmulgee rivers. Prof. G. D. Harris referred strata at Roberts, nine miles east of Macon, to the horizon of the "Woods Bluff" (Bashi), formation of the Wilcox group, but it seems now more probable that they are Claiborne. (See page 279.)

Physiographic expression.—The area underlain by the formation is small and it has produced no notable physiographic features. The topography of the area is rather broken and hilly similar to that of the Midway area to the north.

[1]Note by Dr. Vaughan: "*Endopachys maclurii* suggests Claiborne; while *Cucullaea macrodonta* is usually not later than Wilcox."

Structure.—The strata dip southward or southeastward. No data are at hand for accurately estimating the rate of this dip. It is probably less than 30 feet per mile. No evidence of local deformation was noted, although, doubtless, such may have taken place in the area adjacent to Chattahoochee River, as noted in the case of the Midway formation.

Economic geology.—Friable, glauconitic shell marl occurs at the base of the Wilcox formation at Fort Gaines, and should be of local value as a fertilizer. This marl, in addition to calcium carbonate, carries small percentages of phosphoric acid and potash. Massive beds of white, fire-clay, which probably belong in this formation, occur in the northern part of Randolph County and in Schley and Sumter counties and will probably be of some commercial value in the future.

LOCAL DETAILS

Fort Gaines.—The Chattahoochee River bluff at Fort Gaines, Clay County, affords exposures of great stratigraphic importance. Sections of the bluff have been published by Loughridge,[1] Spencer,[2] Langdon[3] and Veatch.[4] Sections made by different observers differ in details, from the fact that the layers are of somewhat variable lithologic composition.

The following is a section made by Dr. Stephenson:

Section of bluff on Chattahoochee River at Fort Gaines, Ga.

	Feet.
Pleistocene (terrace deposit).	
12. Coarse, red, ferruginous sand, pebbly in lower half	18
11. Pebble and cobble layer, the pebbles and cobbles well rounded; also numerous fragments of greenish, gray, calcareous sandstone	2
Eocene.	
McBean formation.	
10. Greenish gray, laminated clay with fine sand partings, and occasional thin layers of glauconitic sand	8
9. Very glauconitic sand with irregular iron concretions	10
8. Indurated layer of large oysters with sand matrix. Contains also large prints of *Venericardia planicosta*, and in loose glauconitic sand pockets along base small fragile pectens. (Fossils collected	2
7. Light gray, calcareous sand with small scattered fragile shells	10

[1]Tenth Census, Vol. VI, Cotton Production, Georgia, p. 14.
[2]Spencer, J. W., First Report of Progress, Geol. Surv. of Ga., 1890-91, p. 46.
[3]Landon, D. W., Report on the Geology of the Coastal Plain, Ala. Geol. Surv, 1894, p. 406.
[4]Veatch, Otto, Clay Deposits of Georgia, Geol. Surv. of Ga. Bull. 18, 1909, p. 80.

6. Indurated layer of argillaceous, calcareous sandstone with a few prints of fossils	2
Wilcox formation.	
5. Dark gray, calcareous rather coarse argillaceous sand, with scattered lime concretions	12
4. Dark gray, more or less sandy clay with pockets of sand	13
3. Dark gray shell marl with rather coarse sand matrix. Lime concretions irregularly distributed through the marl, especially near the middle of the bed. Contains numerous large pieces of lignite also near the middle of the bed. Shells most numerous 8 to 10 feet above base of section. (The horizon is the same as that from which a collection was made on the west side of river above the bridge at Fort Gaines)	17 to 20
2. Light gray, mealy, very micaceous sand, streaked with iron stain. (This stratum and the preceding separated from the following by a marked unconformity)	0 to 4
Midway formation.	
1. Rather soft, yellowish limestone (stage of water about eight feet above normal)	3 to 10

From Layer No. 8, Dr. Vaughan identified *O. sellæformis, Pecten deshayesii,* and *O. georgiana ?,* and determined the horizon to be Claiborne.

A section and description which includes some details not given in the preceding sections was made by Veatch. The location is about one-fourth mile below the wagon bridge.

Section of Bluff at Fort Gaines.

Pleistocene (terrace deposit)	Feet.
13. Coarse red sand with quartz pebbles in the lower half; caps the bluff . . . . (Unconformity).	15
Eocene	
McBean formation.	
12. Drab, fine-grained, laminated clay with sand partings	8
11. Yellow and grayish glauconitic sand	10 to 12
10. Clay and sand, in part calcareous	20
9. Indurated clay layer or drab claystone; contains fossils and is similar lithologically to the Claiborne claystone east of the town of Fort Gaines	2 to 2½
8. Grayish, argillaceous sand	6
7. Yellowish and gray quartz sand; contains calcareous sand nodules; small pebbles noted at the base; fossils *Xenophora, Venericardia planicosta*	2 to 2½
Wilcox formation.	
6. Gray and black laminated, sandy carbonaceous clay; part of the thickness is indurated and jointed	18

5. Calcareous, compact, argillaceous sand, contains fragile shells and is in the nature of a marl; *Balanophyllia*	8
4. Nodular calcareous layer	2
3. Ash-colored, lignitic sand, unconsolidated bed of small oyster shells, *O. thirsae*, at the base . . .	7
2. Gray, mealy, lignitic sand, variable thickness, in erosion pockets in limestone	4
(Unconformity.)	
Midway formation.	
1. White to yellowish soft massive bedded limestone poorly fossiliferous, contains *O. pulaskensis*, maximum thickness exposed	20

At very low water stages, circular pockets of black, or gray lignitic, argillaceous sand can be seen in the limestone in the bed of the river beneath the wagon bridge.

No. 13 of the section underlies the terrace plain upon which Fort Gaines is situated, and is a Pleistocene terrace deposit.

In the west bank of the river at the wagon bridge, the white sandy limestone of the Midway formation is overlain by three to six or eight feet of friable, sandy, glauconitic marl, in which the shells of the small oyster, *Ostrea thirsae,* are very abundant. Above the marl there is a sandy clay which contains white calcareous nodules.

At the mill and cotton-gin on Commochechebbe Creek, one mile north of town, the Midway-Wilcox unconformity is again well exposed. A lignitic, argillaceous sand fills holes and cracks in the limestone, and the limestone is overlain unconformably by a glauconitic sandy marl which contains in abundance small oyster shells, *O. thirsae,* small fish teeth and fragments of bones.

At the mouth of Flat Creek, four and one-half miles south of Fort Gaines, a glauconitic, sandy argillaceous, shell marl was found in the bed of the creek a few yards above its junction with the river. The creek has cut a narrow trench in the first terrace bordering the river, forming bluffs about 30 feet high. Only two or three feet of marl is exposed above the water, and the upper part of the bluff is a dark, lignitiferous, argillaceous sand, and Pleistocene alluvium. From fossils collected here, Dr. Vaughan has identified:

Cucullaea macrodonta Whitfield
Ostrea compressirostra Say.
Chlamys greggii Harris
Pecten sp.
Ostrea sellaeformis Conrad

The *O. sellæformis* suggests Claiborne strata at this point, while the other fossils are Wilcox in age. However, no other evidence of two Eocene horizons was observed in the field examination. The evidence of Claiborne age afforded by *O. sellaeformis* is not entirely

conclusive since this fossil has also been found in the Hatchetigbee formation of the Wilcox group in Alabama.[1]

The dark colored and drab, laminated sandy clays exposed in the bluff at Fort Gaines can be traced eastward and appear at a number of localities in Clay, Quitman, and Randolph counties. The clays become characteristically glauconitic in these counties, while apparently a considerable thickness of unconsolidated vari-colored, non-calcareous and kaolinic sands lie between the clay and calcareous member of the lower Eocene.

Cuthbert.—An excellent exposure occurs in the public road at Peterson Hill, four and one-half miles northwest of Cuthbert.

Vertical section in strata at Peterson Hill.

	Feet.
Claiborne group ?	
8. Incoherent red sand, very fine	15
Wilcox formation.	
7. Orange-colored, fine-grained, clayey sand, residual	15
6. Gray, silty, laminated clay	
5. Gray, slate-colored and drab laminated clay, contains thin glauconitic layers	55
4. Clay in the nature of fullers earth, slightly glauconitic	
3. Glauconitic layer, a few fossils noted	4½
2. Coarse red and yellow quartz sand, contains a lens of white and yellow massive clay 8 feet thick .	25
1. Rather coarse, current-bedded sand, probably glauconitic near the top	15

What is probably an unconformity between the glauconitic clay and the red sand of the overlying Claiborne group appears in a cut of the Central of Georgia Railway near the 121 mile-post about three miles west of Cuthbert. The Wilcox strata here consist mainly of gray or drab laminated and jointed clay.

The beds lying above the marl and limestone on the upper Lumpkin road to eight miles north of Cuthbert, as exposed in the cuts and gullies along this road, are mainly drab or gray, sandy, laminated clay in the nature of fullers earth. At a few places red, incoherent sand was noted and a bed of white, very pure clay occurs between the five and six-mile posts. The thickness of the strata is inferred from natural exposures to be 125 to 150 feet. Red sand, either Claiborne or Vicksburg, appears on the highest hills.

Weston.—The following section appears in the Weston-Preston public road, one and one-half miles northeast of Weston, Webster County:

[1]Aldrich, T. H., Report on the Geology of the Coastal Plain, Ala. Geol. Survey, 1894, p. 236.

Section one and one-half miles northeast of Weston.

	Feet.
Age ?	
4. Red, sand containing flint fragments; the flint fragments contain characteristic Oligocene fossils	40 to 50
3. Coarse, red sand	10 to 15
Wilcox formation?	
2. Drab, laminated clay, slightly glauconitic; some poorly preserved fossils	20
1. Black, sandy, glauconitic clay	8

Beds 1 and 2 appear to be similar to the clays near Fort Gaines and Cuthbert and probably represent the Wilcox formation.

Plains.—Gray, glauconitic sand appears at Magnolia Spring, two and one-half miles north of Plains, Sumter County, which is also probably a part of the Wilcox, although no fossils were observed.

Ellaville.—Fossils of the Wilcox formation were found south and southeast of Ellaville, Schley County. On the Lumpkin farm, on Goldendale Creek, six miles southeast of Ellaville, fossils were found in fragments of flint in a clay soil. The natural exposures are poor at this locality, and the field observations afford no evidence supplementing that of the fossils. Dr. Vaughan identified the following fossils from this locality:

Fossils from Lumpkin farm, Goldendale Creek.

Cassidulus (?) sp.	Leda pharcida Dall
Actaeon	Glycymeris
Turritella mortoni Conrad	Ostrea thirsae (Gale)
Calyptrea aperta (Solander)	Cardium
Dentalium	Cardium

Andersonville.—The weathered exposures at Andersonville, Sumter county, reveal deep red sands and the fresher exposures in gullies reveal white and red cross-bedded incoherent sands. A thick bed of white clay is reported in a well 90 feet deep, near the station. In a cut of the Central of Georgia Railway, two miles north of Andersonville, 35 feet of white and red, incoherent quartz sand which presents a most wonderful display of cross-bedding, is exposed. Thin beds of limonite or ferruginous sandstone in the loose sands were noted in this vicinity. A sandy clay containing scattered glauconite grains resembling the glauconitic clays of the Wilcox formation was found near Hodge's Mill on Sweetwater Creek, one mile south of Andersonville.

CLAIBORNE GROUP

The Claiborne group, or Claiborne formation, where the strata representing the group are not subdivided into constituent formations, derives its name from the old town of Claiborne, on Alabama River,

once a prosperous village but now represented by only a warehouse and boat-landing. The boat-landing is at the foot of the Claiborne Bluff, one of the classic localities of American geology. It was from a study of fossils collected here that Conrad[1] first recognized the presence of strata of Eocene age in the United States. The Claiborne group is continuous from Alabama into Georgia, where it occupies the same stratigraphic position, above the Wilcox and beneath the Jackson, and is characterized by the same species of fossils as in the former State.

The Eocene age of the marl and limestone at Shell Bluff in Georgia, along with the strata of Claiborne Bluff of Alabama, was first recognized by Conrad.[2] In 1900, Dr. T. Wayland Vaughan[3] visited the Shell Bluff locality and established the Claiborne age of the exposure below the *Ostrea georgiana* bed. In 1908, Prof. S. W. McCallie[4] gave a brief description of the Claiborne and published an extensive list of Claiborne fossils, chiefly identified by Dr. Vaughan, obtained mainly from the region east of Ocmulgee River.

D. W. Langdon[5] first recognized the presence of Claiborne strata on Chattahoochee River, while beds of Claiborne age were first discriminated on the Flint by J. W. Spencer.[6]

The Claiborne group in Alabama is subdivided into three formations,[7] viz.:

Gosport greensand
Lisbon formation
Tallahatta buhrstone

Although in a general way the correlatives of these formations may be recognized in Georgia, the extension of the use of these terms to this State is inappropriate, since the Claiborne group is not naturally divisible into the same units as in Alabama; therefore, in Georgia the group is divided into two formations, with the recognition of a member in one of the formations, viz.:

Barnwell sand
McBean formation, with the Congaree clay member.

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[1]Proc. Acad .Nat. Sci., Philadelphia, 1834, Vol. 7, pp. 116-157.
[2]Amer. Jour. Sci., 2d ser., Vol. 41, 1866, p. 96.
[3]Science, n. s., Vol. 13, Feb. 15, 1901, p. 270.
[4]Bull. Geol. Survey of Georgia, No. 15, 1908, pp. 83, 84, 336-348.
[5]Bull. Geol. Soc. America, Vol. 2, 1891, pp. 597, 598.
[6]Rept. of Progress, Geol. Survey of Georgia, 1890-1891, p. 51.
[7]Smith, E. A., Underground water resources of Alabama: Geol. Survey of Alabama, 1907, pp. 17, 18.

Sloan[1] has proposed a number of phase names for the various aspects of the Claiborne group as it is exhibited in South Carolina, and in two instances the usage of names for subdivisions of the Claiborne group is extended from there into Georgia.

McBEAN FORMATION

NAME

The name McBean is derived from the town of McBean in Richmond County, Ga., and from McBean Creek which forms the boundary between Richmond and Burke counties. The formation to which the name is here applied is well exposed near the town of McBean and southward along McBean Creek to its confluence with Savannah River. According to Dr. Vaughan the formation is equal to the Tallahatta buhrstone plus the Lisbon formation of Alabama, and the top of it may include the base of the Gosport greensand of the Alabama section.

DEFINITION

Stratigraphic relations.—The McBean formation rests unconformably upon strata of Lower Cretaceous age east of Ocmulgee River. This unconformity represents a long interval of time, for the two lower Eocene formations, the Wilcox and Midway, and all of the Upper Cretaceous deposits, aggregating a thickness of 3,000 feet or more, are absent in this region. Tongues of McBean strata also lap over the Cretaceous and even extend to the crystalline rocks of the Piedmont Plain. The most notable of these overlaps are at Roberts, Harlem, and Grovetown.

Between Flint and Chattahoochee rivers the McBean formation rests upon the Wilcox formation. Along Chattahoochee River, in the vicinity of Fort Gaines, there is evidence of an erosion unconformity, probably of minor importance, separating the two formations.

The formation in eastern Georgia is overlain by the Barnwell sand which in this region constitutes the upper formation of the Claiborne group. The relations between the two divisions are somewhat obscure. Along the northern margin of the areal occurrence of the Barnwell sand there is evidence of an unconformity of slight time importance separating it from the McBean formation, but farther southward the former seems to rest upon the latter with conformable relations. It seems probable that near the close of the time of deposition of the McBean formation there was an uplift which brought the northern margin of the area of Claiborne deposition above sea-level, permitting erosion to take place in the emerged area, while deposition continued in the area which remained under water. The uplift was of

[1]Catalogue of mineral localities of South Carolina: Geol. Survey of South Carolina, 1908.

short duration, however, the emerged tract being soon submerged again allowing deposition to continue as before over the whole belt.

The Barnwell sand may be, in fact probably is, present west of Flint River, but as there is some doubt as to its identification in this area there is lack of definiteness regarding the stratigraphic relations between the McBean and the overlying formations.

Lithologic characters.—The formation consists mainly of clays in the nature of fullers earth, shell marls, sandy limestones, and calcareous, glauconitic sands. The marls are for the most part massive-bedded and friable, but hard, compact, and even partially silicified beds were noted on Savannah River. They may also be represented by alternate layers of marl or calcareous sand and laminated clay. The greatest thickness of the marl beds is in the Savannah River bluffs where, at Shell Bluff, there is an exposed thickness of over 100 feet.

The marls of the McBean formation reach their greatest development on Savannah River; they extend southward from Shell Bluff about 11 miles in a direct line to a point one and one-half miles below Griffins Landing, where they appear in the bluff 50 feet above the water level. Westward from Savannah River, marls are exposed near McBean, Louisville, Tennille, Sandersville, and at other localities.

The Flint River exposures are friable, calcareous sands, sandy limestones, marls, and sandstones. On Chattahoochee River, Langdon recognized a lower "Buhrstone" member and an upper calcareous member. The formation here presents a variety of lithological phases as elsewhere—gray, glauconitic limestones and marls resembling those on Savannah River; calcareous clays and claystones, and red and vari-colored unconsolidated sands.

Exposures of the formation are of small areal extent, and the marls and other materials have had but little effect upon the soils of the region underlain by them.

The marls are usually replete with fossils, the casts and shells of mollusca being the most common. Vertebrate remains, fish teeth, fragments of bones, etc., Bryozoa, and corals have been collected.

A portion of the McBean formation consists principally of fullers earth, and drab or greenish sandy clays. This is a depositional phase of the terrane. It is best exposed along the northern margin of the formation, extending approximately from Grovetown, Columbia County, to near Macon. This phase will be described on following pages as the Congaree clay member of the McBean formation.

The McBean formation as a whole presents a marine aspect, and was doubtless deposited near shore and in shallow water.

Thickness.—The thickness of the McBean formation east of Ocmulgee River is estimated at 300 to 400 feet. The maximum exposed thickness occurs at Shell Bluff, Savannah River, where 115 feet of strata were measured. The thickness of the Claiborne group near Louisville, Jefferson County, estimated from the record of an oil-prospecting well, is 350 feet the greater part of which is referable to this formation, although the upper 68 feet may belong to the Barnwell sand. The lithologic character of well drillings from Waynesboro indicate that the maximum thickness of the Claiborne group is not over 500 feet, perhaps less, at this place; all except about 100 feet of this is referable to the McBean formation. In parts of the area over which the McBean is the surface formation, the thickness will vary from not over 50 to 150 feet. The thickness along Ocmulgee and Oconee rivers is certainly much less than that along the Savannah, suggesting that there was probably a basin in the Savannah area during the Claiborne epoch.

Between Ocmulgee and Chattahoochee rivers where the Barnwell sand has not been certainly identified the thickness of the Claiborne group seems to be in general less than in Burke County.

On Chattahoochee River, the estimated thickness of the Claiborne group is 250 to 300 feet. On the Flint, judging from the width of the outcrop, the thickness does not exceed that on the Chattahoochee and is probably less. The thickness between these two rivers, as shown by natural exposures, is not greater than 150 or 200 feet. Southward, under cover of the younger formations, the Claiborne group may diminish in thickness since the combined thickness of the Eocene is not more than 700 or 800 feet as shown by the record of an artesian well at Albany. (See page 317.)

Paleontologic characters.—The most extensive collection from any single locality in the area underlain by this formation was made by Mr. Earle Sloan, at Sloan's Scarp on McBean Creek, between McBean Station and Savannah River. Mr. Sloan submitted his fossils to Dr. Vaughan who contributes the following list and notes.

List of fossils from Sloan's Scarp, McBean Creek. Collected by Earle Sloan.

Endopachys maclurii (Lea)
Ringicula biplicata (Lea)
Conus sauridens Conrad
Pleurotoma kelloggi Gabb
Pleurotoma texacona Harris
Pleurotoma terebriformis Meyer
Pleurotoma childreni Lea
Pleurotoma lesueuri Lea
Pleurotoma nodocarinata Gabb
Turritella arenicola Conrad
Turritella carinata Lea
Mesalia claibornensis (Conrad)
Tuba antiquata Conrad
Amalthea pygmaea (Lea)
Calyptrea aperta (Sol.)
Crepidula lirata Conrad
Lunatia eminula (Conrad)
Natica semilunata Lea

Pleurotoma aff. rugosa Lea
Amblyacrum stantoni Vaughan
Amblyacrum huppertzi var. penrosei Harris ?
Mangelia infans Meyer
Marginella columba Lea
Marginella semen Lea
Caricella demissa var. texana Gabb
Caricella aff. pyruloides (Conrad)
Clavelithes humerosus Conrad
Fusus bellus Conrad
Fusus mortoni Lea
Lirofusus thoracicus (Conrad)
Typhis gracilis Conrad
Pyrula (Fusoficula) texana Harris
Leiorhynus prorutus Conrad
Laevibuccinum prorsum Conrad
Mitrella mississippiensis Meyer & Aldrich
Phos sagenum (Conrad)
Buccinanops altile (Conrad)
Pseudoliva vetusta (Conrad)
Lacinia alveata Conrad
Turritella nasuta Gabb
Turritella nasuta var. houstonia Harris
Sigaretus declivis Conrad
Solarium elaboratum Conrad (young)
Solariorbis depressa (Lea) var.
Dentalium annulatum Meyer
Nucula ovula Lea
Nucula magnifica Conrad
Leda media Lea
Yoldia psammotaea Dall
Arca rhomboidella Lea
Ostrea sellaeformis Conrad
Pecten wahtubbeanus Dall
Crassatellites protextus (Conrad)
Venericardia sp. (also at Lisbon, Ala.)
Venericardia alticostata (Conrad)
Venericardia planicosta Lamarck
Phacoides papyraceus (Lea)
Bornia prima (Ald.)
Cytherea discoidalis Conrad
Metis raveneli (Conrad)
Tellina mooreana Gabb
Pteropsis lapidosa Conrad
Corbula alabamiensis Lea
Corbula densata Conrad
Corbula fossata var. extenuata Dall

"Mr. Sloan also obtained a number of species that I was not able specifically to identify; some of these are new, while others have probably been described, but the groups to which they belong have not been thoroughly studied. This is a most interesting collection as it furnishes an excellent basis for correlation with other South Atlantic and Gulf Coastal Plain States. Deposits of the same age occur at Keitt's Ravine and Lang Syne in South Carolina, where Sloan calls them Warley Hill marl; at Pooser's Hill and Caw-caw Swamp, where they are called Cawcaw shale and marl by Sloan; at Decariduc place, near Aiken, and at Hixon bridge, Tinkers Creek, Aiken County. At the last named locality Sloan calls the horizon Barnwell phase. The horizon in Alabama and Mississippi is represented by the Lisbon formation; in Louisiana by the upper portion of the St. Maurice formation; and in Texas by the Cook Mountain formation.

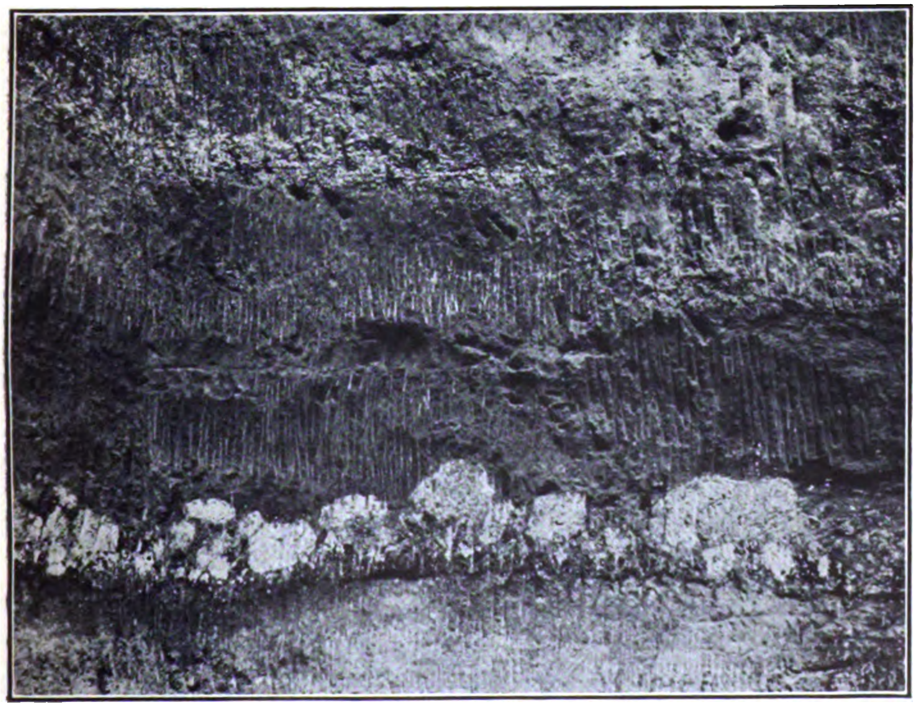
"In Georgia the McBean formation includes two paleontologic horizons. The lower one has been discussed in the preceding remarks. It is especially characterized by *Pleurotoma nodocarinata* Gabb, *Turritella nasuta* Gabb, *Turritella nasuta* var. *houstonia* Harris, *Ostrea sellaeformis* Conrad, *Pteropsis lapidosa* Conrad, and *Corbula fossata* Meyer and Aldrich.

"A higher horizon is represented especially well along Savannah River, between Shell Bluff, upstream, and Griffin's Landing, downstream. Along this stretch of the river a prominent ledge, largely composed of *Ostrea georgiana* Conrad, forms the top of the McBean formation. Although this formation could be subdivided along Savannah River it was found impracticable to extend the subdivision westward, for which reason the *Ostrea georgiana* bed is considered as constituting its upper portion.

"Mr. E. W. Berry has studied the fossil plants of the Congaree clay member and his results are ready for publication as a Professional Paper of the U. S. Geological Survey."

Areal distribution.—Outcrops of the McBean formation occur in an extremely irregular belt, varying from a few miles to 25 miles or more in width, and extending entirely across the State. In the re-

A. *OSTREA GEORGIANA* BED AT SHELL BLUFF, SAVANNAH RIVER, BURKE COUNTY.



B. LAYER OF PISOLITIC CLAY BOWLDERS NEAR THE BASE OF THE CLAIBORNE GROUP IN A PIT OF THE AMERICAN CLAY COMPANY, ELEVEN MILE POST, TWIGGS COUNTY.

gion between Savannah and Ocmulgee rivers this belt lies to the south of the belt in which the Lower Cretaceous strata come to the surface, and between Ocmulgee and Chattahoochee rivers it lies to the south of the area in which the Midway and Wilcox formations outcrop.

On account of the difficulty in distinguishing between the weathered phases of this formation and the overlying Barnwell sand, the Claiborne group has been given one color on the geological map, no attempt being made to map the two formations separately. East of Flint River, exposures have been studied in the following counties: Columbia, Richmond, Burke, McDuffie, Jefferson, Glascock, Washington, Baldwin, Wilkinson, Jones, Twiggs, Bibb, and Houston. Exposures also occur on Flint and Chattahoochee rivers. It is evident that east of Ocmulgee River the formation originally entirely concealed the Lower Cretaceous and lapped over to the crystalline rocks of the Piedmont Plain, but it has been extensively modified by erosion and the northern limit of outcrop, as marked on the map, is a jagged line, since streams have cut through it and exposed the underlying Cretaceous.

Physiographic expression.—Over practically the whole of the area of its occurrence east of Ocmulgee River the formation is overlain by the Barnwell sand, the beds appearing at the surface only in the stream bluffs and on the lower slopes and in the bottoms of the valleys. On account of the compactness of the materials composing it, the formation has been effective in places in preventing the rapid reduction of the valley sides from steep to gentle slopes, but otherwise it has had only a subordinate part in determining the topographic aspect of the region that it underlies.

Structure.—The McBean formation shows a low dip southward. The dip of individual beds is so slight that they appear horizontal in natural exposures. The slope southward for the formation as a whole is perhaps not more than 10 or 15 feet per mile. No pronounced folding or faulting of beds has been observed. Langdon[1] noted low flexures along Chattahoochee River; only purely local disturbances such as might be due to land slips or weathering and solution of calcareous strata, were noted in the Ocmulgee-Savannah area. The thick clay and fullers earth beds show minute jointing. Clay laminae show slight crumpling at a few localities but this is of doubtful regional significance. An exposure of the McBean occurs four and one-half miles south of Perry, Houston County, at an elevation higher than Jackson outcrops lying to the north. The structural relations are unexplained. It is probable there has been folding or faulting.

[1]Langdon, D. W., Report on the Coastal Plain; Geol. Survey of Alabama, 1849, p. 389.

LOCAL DETAILS

MCBEAN CREEK AREA, RICHMOND AND BURKE COUNTIES

McBean and vicinity.—McBean, Richmond County, is situated on the Central of Georgia Railway, 22 miles south of Augusta. The exposures of the McBean formation are principally on the south or Burke County side of McBean Creek. The following notes are by Dr. T. Wayland Vaughan:

Section in gully on south side of McBean Creek, one-quarter of a mile south of McBean Station.

	Feet.	In.
Barnwell sand.		
5. Silicified coquina rock imbedded in sand		
4. Yellow and white sands, portions very fine, others coarse	32	6
McBean formation.		
3. Drab clay forming an indurated stratum, some lignitic matter	1	6
2. Greenish-yellow, rather fine-grained, argillaceous sands, with black specks and lignitic pockets. These sands becoming variably yellow and red	6	
1. Light greenish-yellow, non-laminated clay, with a little calcium carbonate	2	6

Gully 300 or 400 feet east of the preceding. Southern end of gully.

Barnwell sand.		
5. Red, sandy clay	2	
McBean formation.		
4. Thin seam of lignite		1½
3. Greenish clays, containing lignite	5	6
2. Marl with calcareous concretions	6	
	Feet	In.
1. Greenish-yellow, calcareous clay	1	

Western side of gully.

Barnwell sand.		
5. Red sands	3	9
McBean formation.		
4. Greenish clay similar to No. 2	0	7
3. Thin seam of lignite following irregular contour of upper surface of No. 1 (corresponds to No. 4 of preceding section) and 2. Greenish clay		2
1. Greenish-yellow calcareous marl	2	

Eastern side of gully.

Barnwell sand.		
3. Reddish sands		
McBean formation.		
2. Greenish-yellow lignitic clay		
1. Calcareous marl with *O. sellaeformis*		

Westerly exposure at McBean Creek, three-tenths of a mile west of Bates Miller's store.

Barnwell sand.		
2. Yellow, gray, and red sands	32	6
McBean formation.		
1. Soft, chalky limestone, indurated in places, containing *Turritella carinata*, *Nucula ovula*, *Corbula gibbosa*, *Pteropsis lapidosa*	12	

Along the road to Thos. B. Cox's house deep red, compact sands, and decomposed glauconite with pebbles near base, are seen overlying the material composing the preceding sections. Large masses of silicified coquina and chalcedony (buhr-rock) with numerous poorly preserved fossils, *Mortonia, Turritella obruta, Corbula alabamiensis*, etc., Claiborne fossils, occur from eight feet of the base to the hill summit. The observed thickness along this road was 52 feet.

Section on Thos. B. Cox's land, six miles southeast of McBean station, from his residence to creek, one-half mile to the northeast.

	Feet.
Barnwell sand.	
4. Red sand with "buhr-rock"	105
McBean formation.	
3. Blue-green gray shale, nonfossiliferous	20
2. Glauconitic, friable, or indurated limestone (chalky) with Claiborne fossils	4
1. Blue clay with rotten calcareous fossils (Claiborne) *Corbula alabamiensis*	1

SAVANNAH RIVER, BURKE COUNTY

Shell Bluff.—Shell Bluff is a classic locality and stratigraphically one of the most important exposures in the Georgia Coastal Plain. The bluff is located in Burke County, on Savannah River, 40 miles by river below Augusta, and 15½ miles by the public wagon road, northeast of Waynesboro.

The bluff has been referred to in geologic literature more often than any other Georgia locality. Probably the first reference was made by William Bartram,[1] the English traveller, in 1791. Prof. John Finch[2] probably had this locality in mind in a paper published in 1824, though it is not mentioned specifically. Vanuxem[3] furnished the first geologic description of any consequence, for a paper read by S. G. Morton in 1828, and regarded the strata as upper Tertiary. The fauna of the bluff was studied by Conrad,[4] 1834, who was the first to classify the beds as Eocene. He gave the name *Ostrea georgiana* to the common oyster, although this fossil was apparently known to Vanuxem[5] before this date and was named by him *Ostrea gigantea*. This locality was visited by Sir Charles Lyell in 1842, and is described in "Travels in North America," published in 1845. Lyell[6] collected 40 specimens and determined the rock to be Eocene.

The stratigraphic position of the beds was a subject of discussion in 1866, when Conrad[7] proposed the name "Shell Bluff Group" for strata characterized by *Ostrea georgiana*, and which he placed below the "Orbitolite limestone of the Jackson group." Hilgard,[8] however,

[1]Travels through North Carolina, South Carolina, Georgia and West Florida, etc.. Philadelphia. 1791.
[2]Amer. Jour. Sci., Vol. 7. 1824, pp. 31-43.
[3]Jour. Acad. Nat. Sci., Philadelphia, Vol. 6. pp. 59-71.
[4]Idem. Vol. 7, 1834, pp. 156-157.
[5]Ibid, Vol. 6, 1830.
[6]Travels in North America, Vol. 1. p. 158. John Murray. 1815.
[7]Amer. Jour. Sci. 2d ser., Vol. 41, 1866, p. 96.
[8]Ibid. Vol. 42, 1866, pp. 68-70.

placed the "Shell Bluff group" above the Jackson, and disputed the occurrence of *Orbitoides* below the Vicksburg. Dr. W. H. Dall,[1] in 1895, placed the "Shell Bluff group" under the lower Oligocene or Vicksburgian, but stated that its position was not definitely settled. Dr. Vaughan[2] made paleontologic studies later and concluded that the marl below the *Ostrea georgiana* bed belonged in the lower portion of the Claiborne group of the Eocene.

Recent studies of the strata by the writers in the vicinity of Shell Bluff post-office, Burke County, and Hancock Landing, Savannah River, have established the fact that the *Ostrea georgiana* bed, 75 to 110 feet above Savannah River, and the overlying red sands should also be referred to the Claiborne group.

Sections and descriptions of the bluff have been published by Ruffin,[3] Loughridge,[4] W. B. Clark,[5] and Earle Sloan.[6] Sections made by different observers vary greatly in detail,—the variations are perhaps due in the main to the imperfection of the exposures and to the fact that the sections were made at different points along the bluff; also, to differences in the usage of descriptive terms, completeness or incompleteness of the sections, and to the object in view, whether stratigraphic or economic.

The length of the bluff against which the river impinges is about 1,000 feet and it attains a maximum height of 150 feet. According to the reports of the U. S. Army Engineers the river level here is 87.1 feet above sea-level.

Dr. Vaughan has made careful stratigraphic studies here and has supplied the following section and notes:

Section of Shell Bluff, mouth of Boggy Gut Creek, on Savannah River.

	Feet.
15. Soil and humus	
McBean formation.	
14. Indurated fossiliferous limestone	1
13. Softer limestone with some sand, (in the uppermost part of this a specimen of *Pteropsis lapidosa* was collected)	6.5
12. Ledge of hard limestone	3.4
11. Softer sandy stratum	3.7
10. Harder stratum	1
9. Softer stratum	1.1
8. Whitish limestone, blotched yellow or brown, with Claiborne fossils	4.25

[1]U. S. Geol. Surv., 18th Ann. Rept., pt. II, p. 342.
[2]Sci., n. s., Vol. 13, p. 270, 1901.
[3]Report of Commencement and Progress of the Agricultural Survey of South Carolina.
[4]Tenth Census, Vol. 6, pt. 2, p. 280 (bottom pagination).
[5]Bull. U. S. Geol. Survey No. 83, p. 55.
[6]Catalogue of mineral localities: Geol. Survey of South Carolina, p. 271.

		Feet.
7.	Yellow sand, more calcareous at top, containing *Ostrea sellaeformis*	13
6.	Softer ledge	7
5.	Harder limestone ledge	4.5
4.	Softer ledge	.5
3.	Harder ledge	2.3
2.	Soft limestone, whitish or yellowish, loosely granular	5.5
1.	Talus above water's edge	7

"The whole section at Shell Bluff Landing is not well exposed because of talus coverings of portions of it. The base of the *Ostrea georgiana* bed is about 80 feet above zero water level in the river, or between 70 and 75 feet above the river bank at the landing. There is 8 to 12 feet of the section unexposed. The total thickness of the *Ostrea georgiana* bed is approximately 24 feet, above which are yellowish sands and soil.

Detailed section of a portion of the Ostrea georgiana bed is as follows:

McBean formation.		Feet.
9.	The upper 9½ feet of thickness of this bed is largely talus-covered, but fragments of oysters were found on the surface, and it was inferred that the thickness is approximately as represented	9.5
3.	Calcareous conglomerate containing small quartz pebbles and poor fossils, one of them a coral, apparently *Cladocora*	3.5
2.	Talus of yellowish sands	6
1.	Oyster ledge	5

Top of stratum No. 13, Shell Bluff, Ga., near mouth of Boggy Gut Creek:

Pteropsis lapidosa Conrad

Stratum 11, *near mouth of Boggy Gut Creek*:

Ostrea sellaeformis Conrad

Stratum No. 8 *or* 9 *near mouth of Boggy Gut Creek*:

Carophyllia subdichotoma Lons.
Dendrophyllia sp.
Endopachy maclurii (Lea)
Plejona petrosa (Conrad)
Fusus trabeatus Conrad
Fusus limulus Conrad ?
Fusus irrasus Conrad ?
Calyptraea aperta (Solander)
Crepidula lirata Conrad
Dentalium thalloides Conrad
Nucula magnifica Conrad
Leda pharcida Dall ?
Glycymeris trigonella (Conrad)
Glycymeris sp. indet. (?) staminea (Conrad)
Crassatellites protextus (Conrad) var.
Venericardia planicosta Lamarck
Venericardia alticostata (Conrad)
Cytherea texacola Harris
Cytherea perovata Conrad ?
Cytherea discoidalis Conrad
Cytherea poulsoni Conrad ?
Corbula alabamiensis Lea
Cobula oniscus Conrad
Corbula fossata Meyer and Aldrich

Stratum No. 8, near mouth of Boggy Gut Creek:

Endopachys maclurii (Lea)
Turritella (Mesalia) vetusta Conrad
Turritella humerosa Conrad ?
small variety
Nucula magnifica Conrad ?
Ostrea sellaeformis Conrad
Cytherea sp.
Pteropsis lapidosa Conrad
Lunulites bouei Lea
Oxyrhina desori Agassiz

Stratum No. 3, near mouth of Boggy Gut Creek:

Marginella constrictoides Meyer and Aldrich
Turritella (Mesalia) vetusia Conrad ?
Nucula magnifica Conrad
Pecten sp.
Corbula fossata Meyer and Aldrich

Shell Bluff Landing, from horizon below the Ostrea georgiana bed and the same as stratum No. 8 of the Boggy Gut Creek section.

Coral—Astrangia?
Mesalia claibornensis (Conrad) ?
Turritella humerosa Conrad ?
small variety
Calyptraea aperta (Sol.).
Leda sp. indet.
Ostrea alabamiensis Lea.
Venericardia planicosta Lam.
Nucula (internal cast, probably magnifica Con.).

Besides these: Lima? fragment, and a large gastropod, apparently a Naticoid.

"The strata in the bluff at Shell Bluff from the base upward including bed No. 13 correspond in stratigraphic position to the Lisbon formation and probably a portion of the Tallahatta buhr-stone of Alabama."

The following section was made by the authors at a point about 200 yards above the boat landing:

Section at Shell Bluff.

	Feet.
Barnwell sand.	
10. Slope, true character of the rock largely concealed; upper part red sand with thin covering of gray sand	70
McBean formation.	
9. Poorly exposed; fragments of *Ostrea georgiana*: strata probably calcareous sand and argillaceous limestone	20
8. Hard, white limestone, full of shells	1
7. White calcareous clay and sand with thin layers of pure limestone	15
6. Light, yellow or brown, fine sand, only slightly calcareous, partly consolidated	8
5. Soft, calcareous sandstone	8
4. Hard, calcareous sandstone full of comminuted shells	3
3. Soft, friable, sandy marl	4
2. Hard, sandy limestone	1
1. Yellowish, friable, sandy marl, glauconitic	12
Total	142

The following section occurs just below the boat landing and is partly exposed in the wagon road leading to the top of the bluff:

Section below the landing at Shell Bluff.

Eocene	**Feet.**
Barnwell sand.	
4. Yellow and gray incoherent sand	**5**
3. Partly concealed, but largely coarse, red sand . .	**20**
McBean formation.	
2. Sandy and argillaceous marl, varying in hardness; contains some quartz pebbles as much as one inch in diameter. Large oyster shells were found at 110 feet above the river, and a conspicuous bed of *Ostrea georgiana* occurs 75 feet above the river. The shells are also found in soil at lower elevations but these may have rolled down from the higher beds	**90**
Recent and Pleistocene.	
1. Talus and alluvium to river level	**20**

The calcareous rock at Shell Bluff, taken as a whole, is a sandy and argillaceous marl. It presents variations from comparatively pure limestone through highly argillaceous and sandy marls to brown friable sand, only slightly calcareous. Silica and clay predominate over lime and the rock often presents the aspect of a fine sand in a matrix of clay and calcium carbonate. The sand which is in microscopic particles consists mainly of angular quartz; scattered, reddish-brown needles, which are probably rutile, were also noted, and a very small amount of white mica was observed. The calcium carbonate is finely disseminated and is also in the form of shells and fine fragments of shells. Glauconite occurs but is not abundant. Small brown or black particles of fossilized bones appear in the rock in the lower part of the bluff and larger fragments are occasionally found. Some of the marls contain scattered quartz pebbles from the size of a pea to an inch in diameter. The materials present a variety of colors such as white, gray, yellow, buff, and yellowish-green, although the aspect, as a whole, is white or gray. Shells of the large oyster, *Ostrea georgianna*, from which the bluff received its name, are conspicuous from 80 to 100 feet above the river level. The shells are usually long and narrow, having a length of 12 to 15 inches and a width of three or four inches; the valves are thick, often two inches. Very large specimens may have a length of 22 inches. Many specimens of the young are curved or sub-oval in shape. As pointed out by Dall,[1] this species is characterized by "low, flattish, distally forked radial riblets, quite different from anything observed on the surface of *O. mauriciensis* or *O. virginica.*"

Rock of the same general lithologic character as that at Shell Bluff extends southward in the Savannah bluffs to a point one and one-half miles below Griffin's Landing, 17 miles by river from Shell Bluff.

[1]**Trans. Wagner Free Ins. of Sci., 1903, p. 1555.**

This is the last point at which it appears in the river bluffs, although probably it is near the surface still farther southward and lightly concealed by the overlying sand.

Demerie's Ferry.—Very fossiliferous limestone and calcareous sand similar to that at Shell Bluff appear a short distance above Demerie's Ferry, one and one-half miles below Shell Bluff. The calcareous bed at this point has an exposed thickness of 20 feet but it probably makes up the bluff to a height of 40 feet above the river. The marl and limestone bed is overlain by 50 to 60 feet of bright red argillaceous sand (Barnwell sand). The fact that the top of the marl is here only 40 feet above the river whereas at Shell Bluff it is over 100 feet above the same datum, means either that the red sands overlie the marls unconformably, or that the beds change from marl to calcareous sand or even to pure sand, in a short distance horizontally or that the true character of the strata above the limestone is concealed by weathering and creep. The last explanation seems most plausible.

A portion of the bed is a silicified mass of fossils. *Venericardia planicosta* and a small coral, *Endopachys maclurii,* are abundant.

Hancock Landing.—Hancock Landing is about 11 miles by river below Shell Bluff. The bluff at the highest point is about 120 feet (aneroid reading) above river level. The rock exposed consists of limestone, friable marl, brown calcareous sand, greenish or bluish calcareous clay, and local beds of quartzite. Beds of ash-colored marls occur at the base of the bluff; the marl contains glauconite and a variable percentage of quartz sand. The upper part of the bluff is a brown and red sand, poorly exposed. *Ostrea georgiana* was noted here at a point 80 feet above the river, and it also appears at lower levels. The specimens show the characteristic ribbed markings. The beds in the lower part of the bluff, contain in addition to a large number of mollusca, fragments of bones, fish teeth and dental plates.

The Hancock Landing bluff recedes from the river for a short distance and is again washed by the river at Utley Point, one-half mile below. Here, there is about 20 feet of ash-colored marl at the base of the bluff, similar to that at Hancock Landing. The strata at the upper end of the bluff are partly concealed by humus and talus. On account of the occurrence of *Ostrea georgiana* a description of this exposure is given.

Section at Hancock Landing.

	Feet.
Barnwell sand.	
8. Red, argillaceous sand, poorly exposed; contains no hard rock, and seems to be devoid of fossils	40

		Feet.
McBean formation.		
7.	Sandy, aluminous marl; contains large shells of *Ostrea georgiana;* other fossils are *Endopachys maclurii, Calyptrea aperta, Turritella carinata, Venericardia, Modiolus.* This stratum is 80 feet above the river. Thickness exposed . .	5
6.	Concealed by humus and talus; soil contains large oyster shells	35
5.	Sandy limestone, containing *Ostrea georgiana.* This may have rolled down from a higher level, but the rock is unlike bed No. 7	4
4.	Strata concealed	15
3.	Laminated clay	4
2.	Poorly exposed, but probably in the main, bluish, sandy marl, and rather hard, bedded clay . .	15
1.	Concealed to the river level	7

Blue Bluff.—This bluff is two miles below Hancock Landing. The lower part is a gray or ash-colored glauconitic marl which assumes a bluish color due to moisture. The section about one-third mile above the bluff proper is:

Section about one-third mile above Blue Bluff.

		Feet.
Barnwell sand.		
5.	Brownish, incoherent sand, forms a thin veneer over the plateau	60
4.	Strata almost entirely concealed, small exposure of red argillaceous sand	
3.	Red sand, exposed on roots of blown-over trees .	
2.	Laminated, drab and greenish, sandy clay, partly concealed	10
McBean formation.		
1.	Bluish and ash-colored, glauconitic marl; variable in percentage of clay and sand. At the base contains lines of white and blue limestone nodules. The marl is fossiliferous and contains the characteristic McBean species *Ostrea sellaeformis* and *Pteropsis lapidosa* . .	40

According to Dr. Vaughan, the basal bed of this section represents a horizon below the Gosport greensand of Alabama, probably within the Lisbon.

The part of Blue Bluff washed by the river shows the following:

Section of part of bluff washed by the river.

		Feet.
McBean formation.		
2.	At top, grayish and brown argillaceous marl and thin bedded layer of jointed, aluminous sandstone. The upper part of the bluff lighter in color and more argillaceous than the lower part	25

	Feet.
1. Bluish, glauconitic marl, massive bedded, contains white fragile shells and casts; fossils, *Turritella nasuta*, *Leda pharcida*, *Lucina subvexa*, *Pteropsis lapidosa*	12

"Stratum 1 represents a horizon in the lower portion of the Claiborne." T. W. V.

The lower end of Blue Bluff shows a bluish marl which is similar to that in the sections described, and which contains limestone nodules. The marl is overlain by 50 feet of red, yellow and gray unconsolidated sands. These sands contain clay laminae, rarely small pebbles, and near the base imperfectly preserved fossils.

Griffin Landing.—This locality is three miles below Blue Bluff, and 147 miles above Savannah. The large fossil oyster, *Ostrea georgiana,* is conspicuous in certain layers.

Section at Griffin Landing.

	Feet.
Barnwell sand.	
6. Gray, structureless sand covering the upland, probably residual	
3. Red, rather coarse, quartz sand, free from pebbles; glauconitic?	100
4. Brown or yellow argillaceous sand, glauconitic .	
McBean formation.	
3. Large specimens of *Ostrea georgiana* embedded in greenish-gray argillaceous sand and drab-clay	10
2. Drab, laminated clay in the nature of a fullers earth; not a persistent bed	5
1. Bed of large *Ostrea georgiana* in a matrix of pale greenish-clay; one specimen found which measured 20 inches in length; in addition to *Ostrea georgiana*, contains *Calyptrea aperta*, *Modiolus*, *Balanus*	10

Lime-kiln Bluff.—Exposures of stratigraphic interest occur in the bluff one and one-half miles below Griffin's Landing. Next to Shell Bluff, this is the highest bluff along the river; the level of the upland to the west was estimated to be 140 feet above the river. This is the site of an old lime-kiln, and since no local name for the bluff is known, the name "Lime-kiln" bluff is an appropriate designation.

Section at Lime-kiln Bluff.

	Feet.
Barnwell sand.	
5. Surface covered with gray sand	
4. Largely concealed, but probably yellow or red sand	80
3. Brown and red sand	

McBean formation.	Feet.
2. Thinly laminated clay, with micaceous sand partings, grades downward into layers No. 1 .	10
1. Sandy and clayey marl, both friable and consolidated; glauconitic; contains oyster shells, casts of other fossils, fish teeth and small fragments of bones	50

Another part of the bluff shows:

Barnwell sand.	
7. Slope, largely concealed, but probably sand and clay . . . . (about) .	50
McBean formation.	
6. Laminated clay with sand partings and thin layers of aluminous sandstone	20
5. Marl, containing *Flabellum cuneiforme, Dendrophyllia, Calyptrea aperta, Ostrea*	2 to 3
4. Sandy, laminated clay	3
3. Bed composed of large oyster shells, *Ostrea georgeorgiana* in a matrix of sandy marl	20
2. White, massive bed of sandy marl; a few oyster shells in the upper part	20
1. Concealed to river level	5 or 6

The marl formation from Shell Bluff southward is regarded as representing a single formation of the Claiborne group, for no basis for a division was discovered. The red sands in the upper part of the bluffs are also regarded as part of the Claiborne group; there seems to be a transition from the marl to the red sands.

RICHMOND COUNTY

Hephzibah.—Marl of the McBean formation occurs on the farm of W. G. Tarver on McBean Creek, six miles south of Hephzibah, where *Pteropsis lapidosa* was collected. The exposure is on the edge of the swamp at McBean Creek where one foot of the marl bed appears. The overlying red sand of the Barnwell division has a thickness of 50 or 60 feet. The marl bed lies at a lower level than the base of the Claiborne group at Hephzibah and probably is underlain at a slight depth by Crètaceous strata. Across this territory there is a marl bed (McBean formation) bearing a lower Claiborne fauna overlain by red sand which seems to correspond to similar lithologic material (the Barnwell sand) in the vicinity of McBean, where it contains an upper Claiborne fauna.

JEFFERSON COUNTY

Louisville.—The character of the strata of the Claiborne group in this region may be ascertained from the record of an old oil prospecting well, three and one-half miles southwest of Louisville. From an examination of the borings it is believed that the base of the Clai-

borne is reached at about 350 feet. The record of the upper part of the well is taken from the report on the Underground Waters of Georgia by S. W. McCallie.[1]

Partial log of oil prospecting well near Louisville.

Mixed clay and sand	from	0	to	68
Sand and rock	"	68	"	74
Blue clay	"	74	"	76
Blue clay and sand	"	76	"	91
Blue clay	"	91	"	93
Sand	"	93	"	96
Hard rock	"	96	"	96
Soft sand rock	"	96	"	99
Sand	"	99	"	113
Hard rock	"	113	"	114
Sand	"	114	"	116
Soft rock	"	116	"	119
Hard rock	"	119	"	120
Blue clay	"	120	"	132
Sand rock	"	132	"	142
Sand and clay	"	142	"	150
Blue clay	"	150	"	169
Sand	"	169	"	171
Blue clay and shale	"	171	"	176
Hard rock	"	176	"	177
Blue clay and sand layers	"	177	"	184
Hard rock	"	184	"	188
Sand	"	188	"	204
Hard rock	"	204	"	205
Blue and white clay	"	205	"	208
Hard rock	"	208	"	209
Sand	"	209	"	213
Shale	"	213	"	219
Sand	"	219	"	223
Blue clay and shale	"	223	"	269
Fine sand	"	269	"	275
Clay and shale	"	275	"	298
Fine sand	"	298	"	307
Sand	"	307	"	505

It will be observed that no thick beds of either limestone or marl were encountered. The rock is principally sand, with a lesser amount of clay, containing shells. None of the borings indicated anything approaching pure limestone. The "hard rock," is probably sandstone or quartzite. With the exception of perhaps the first 68 feet, all of the strata in the section down to about 350 feet belongs to the McBean formation.

A bed of oyster shells and marl found at Warren's Mill, three miles east of Louisville is reported to have been excavated to a depth of seven feet, the rock being used in the concrete work of a mill dam. There are no natural exposures. This rock is overlain by a bed of

[1]Geol. Surv. of Ga., Bull. 15, 1908, p. 129.

fullers earth-like clay, which in places is rich in animal remains—shells, teeth, bones, etc. The surface formation is red sand.

WASHINGTON COUNTY

Sandersville.—A soft, white argillaceous limestone appears at the limesink on the B. T. Rawlings property, three-fourths mile south of the court house. The maximum thickness exposed is 10 feet. Fragments of an oyster, *Ostrea georgiana,* and *Mortonia* are abundant; the latter is so common as to attract local attention and is styled "lime biscuit." The marl is overlain by red sand containing white sandstone beds.

Sandstone containing *Ostrea georgiana* and thin layers of quartzite occur at "The Spring" on the east side of the road, a short distance east of the limesink.

Prof. S. W. McCallie has furnished the following description of a section at Rocky Branch bridge two miles northwest of Sandersville, (unpublished notes:)

Section at Rocky Branch Bridge.

	Feet.
Barnwell sand.	
4. Reddish clays	10
3. Sandstone	8
McBean formation.	
2. Greenish sandy, glauconitic clay weathering yellow. This clay in places becomes silicified into flint-like layers, the total thickness being about	8
1. Greenish glauconitic sand with shark's teeth and fragments of bone. About 100 yards further down the creek and apparently underlying the greenish glauconitic sands is a greenish, finely laminated clay with fragments of shells and plants	

The exposure in the vicinity of the spring, one mile south of Sandersville Court House, consists of sandstone mostly as loose boulders in the soil. The only fossils noticed here were oysters which are always more or less fragmentary.

A section at Limestone Creek, two miles south of Sandersville, made out from several exposures along the stream seems to be as folows:

Section at Limestone Creek.

	Feet.
McBean formation.	
3. Sandstone with oyster shells (near top)	10
2. Sands and possibly some clay (only partially exposed)	10
1. Rotten fossiliferous limestone	20

The exposure along the creek is not continuous and the section here given is only approximately correct.

Tennille.—A soft, argillaceous marl occurs in a gully along the Central of Georgia Railway near the 139 milepost.

Section at 139-Mile Post.

		Feet.
Barnwell sand.		
5.	Bright, red sand, fresh exposures not seen	10
4.	Fragmentary, siliceous layer; contains fragments of an oyster and *Scutella*	1½
3.	Coarse,brown and yellow sand	10
2.	Interval concealed, probably sand	4
McBean formation.		
1.	Soft, calcareous rock, glauconitic and probably contains a higher percentage of clay than lime; casts of fossils abundant	12

Prof. McCallie has compiled the following section from exposures between the 138 and 139 mile-posts (unpublished notes):

Section between Mile-posts 138 and 139.

		Feet.
Barnwell sand.		
9.	Surface sands	0-3
8.	Massive, orange-colored, sandy clays unconformable with beds below	10
7.	Stratified sands and clays with fragments of oyster shells	12
6.	Sandstone often fossiliferous along the parting planes	4
McBean formation.		
5.	Greenish-gray clayey sand with fragments of oyster shells	3
4.	Whitish, putty-like clay with layers of flint containing fossils	(?)
3.	Sandy, glauconitic clay	3 (?)
2.	Fossiliferous, soft limestone with hard ledges .	10 (?)
1.	Bluish, tough clay with sand partings	

The following fossils were obtained by Prof. McCallie at this locality:

Fossils from near Tennille.

Glycymeris trigonella (Conrad)	Corbula alabamiensis Lea
Glycymeris idonea (Conrad)	Crassatellites altus (Conrad)
Mortonia sp., the common Eocene species of eastern Georgia	Crassatellites protextus var. lepidus Dall
Endopachys maclurii (Lea)	Ostrea alabamiensis Lea

According to Dr. Vaughan the geologic horizon is Claibornian and seems to be in the uppermost portion, i. e., above the *Ostrea sellaeformis-Pteropsis lapidosa* zone, or the fossils come from the Barnwell sand.

Sunhill.—A bed of compact, crystalline limestone outcrops one-quarter of a mile south of the depot, and was at one time used in the manufacture of lime.

Section at old lime-kiln, Sunhill.

	Feet.
Barnwell sand.	
3. Dark, red, fine-grained, sand, surface aspect due to weathering, contains vitreous flint, probably due to replacement of a calcareous rock	15
2. Argillaceous sand	1.5
McBean formation ?	
1. White, compact limestone, containing shells and Bryozoa; *Flabellum cuneiforme* Lonsdale, *Venericardia alticostata*, etc.	6+

Davisboro.—Large boulders of flint, which are residual and evidently a replacement of limestone, occur two miles southeast of Davisboro, on the property of S. J. Taylor, on a small tributary of Williamson's Swamp Creek. The rock contains poorly preserved fossils and has the appearance of the flint of the Claiborne group.

The following section occurs at Tarver's Mill, eight miles southeast of Davisboro:

Section at Tarvers' Mill.

Pliocene ?	Feet.	In.
Altamaha (Lafayette?) formation		
6. Mottled argillaceous sand covered with gray sand	10+	
Eocene.		
Barnwell sand (?)		
5. Red sand	20	
4. Red and yellow sand	12	
3. Clay layer	0	6
2. Yellow and white quartz sand	15	
McBean formation.		
1. White, sandy claystone; contains fragments of shells and sharks teeth, exposed to water's edge	5	

There are no data to establish the stratigraphic position of the beds here definitely; the succession, red and yellow sands over clay, suggests identity with sections of the Claiborne group elsewhere.

TWIGGS COUNTY

The northern part of Twiggs County presents much the same succession of beds as Wilkinson County, (see page 293.)—namely, red and vari-colored sands over drab, massive and laminated clays and fullers earth, both of which rest uncomformably upon white clay beds and kaolinitic sands of the Cretaceous. There are also beds of sandstone, quartzite, and limestone in the Claiborne group.

Dry Branch.—Fine exposures appear at the various clay mines near Dry Branch.

Section at the mines of the Georgia Kaolin Company, two miles southeast of Dry Branch.

Barnwell sand.	**Feet.**
5. Fine, red sand observed along the slope to the top of the ridge—dark, red color, probably a surface phenomenon due to weathering . .	100
McBean formation?	
4. Greenish and drab, faintly laminated clay of low specific gravity, contains casts of fossils; contains local lenses of soft, friable limestone, a foot or two in thickness	15
3. Fine, yellow, quartz sand	12
2. Soft, white limestone, and limestone and kaolin breccia; contains characteristic Claibornian fossils, corals, a large oyster, *Nucula ovula* Lea, *Leda sp.*, *Crassatellites altus* (Conrad), *Venericardia planicosta Lamarck*, *Cytherea perovata* Conrad, etc.	4
(Unconformity)	
Lower Cretaceous.	
1. Massive beds of white clay	20

Stratum No. 2 presents a curious breccia, consisting of soft fossiliferous limestone and chunks of white clay. The white clay was evidently derived from the underlying bed but the limestone is in its place of origin.

Another local development of limestone appears in a ravine a short distance southeast of the mines. This lies 10 to 15 feet above the Cretaceous, but from the fossils it is known to belong to the Jackson formation, (see page 304.)

Gallemore.—A fossiliferous marl or limestone occurs in the bed of the creek at the mill near Gallemore or Willis Station. The rock is a bluish-gray, siliceous marl which in places is indurated. It consists of fine quartz sand, imbedded in a matrix of clay and calcium carbonate, and has much more the lithological aspect of the McBean formation than of the Jackson or the Vicksburg, which appear a short distance farther south. Fossils are abundant, and an oyster was noted, the species of which has not been determined.

Prof. McCallie collected the following fossils at Gallemore Station, Twiggs County:

Fossils from Gallemore Station.

Plejona pretosa (Conrad)
Calyptrea aperta (Solander)
Turritella carinata Lea
Mesalia vetusta (Conrad)
Leda sp.
Glycymeris sp.
Diplodonta ungulina (Conrad) ?
Phacoides alveatus (Conrad)
Corbula sp.

The following succession of beds was noted at Rocky Hill, one mile southwest of Gallemore:

Section at Rocky Hill.

	Feet.
Barnwell sand.	
3. Red sand similar to the Barnwell sand at other localities	40
2. Siliceous limestone or flint	8
McBean formation.	
1. Drab, clay, laminated, porous, and like fullers earth	(?)

South of this locality the Altamaha (Lafayette ?) and Vicksburg formations appear at the surface.

In the western part of the county there are numerous exposures showing the McBean formation in contact with the Cretaceous. At a point one mile south of Bond's store, or Delzel postoffice, the Congaree clay member reaches a thickness of 80 feet and is overlain by red sand. The red sand of this formation, which is frequently coarse and contains limonite crusts and hollow nodules, is in places in contact with the Cretaceous, the heavy fullers earth-clay beds being absent. Local beds of limestone are reported.

AREA WEST OF OCMULGEE RIVER

The strata between Flint and Chattahoochee rivers present a close general lithologic similiarity to those of the eastern area. Along the northern margin of the formation, red, rather coarse sands at the surface overlie laminated or thin bedded clay, while southward or seaward the beds are calcareous, and sandy marls, very similar to those along Savannah River, interbedded with clay, are overlain by red sand similar to the Barnwell sand. Flint appears to be absent, but there are occasional thin sandstone or quartzite layers in the sand. Clay or fullers earth is less extensively developed, but this phase is represented by drab, laminated, fossiliferous clays, such as occur at the base of the formation at Fort Gaines.

Within the area lying between Ocmulgee and Chattahoochee rivers exposures of strata belonging to the Claiborne group have been examined four and one-half miles south of Perry, Houston County; along Flint River at several localities, notably at the old Danville Ferry and at Penny Bluff; and along Chattahoochee River for a considerable distance below Fort Gaines. Other localities in the Chattahoochee drainage area are described on subsequent pages of this paper. Fair collections of fossils have been obtained from a number of exposures rendering it safe to state that the McBean formation extends uninterruptedly from Savannah to Chattahoochee rivers. However,

the formation is often masked by later deposits ranging in age from Jackson and Vicksburg to perhaps Pleistocene. The red, rather coarse sands that underlie the Vicksburg and overlie the recognizable McBean may be the westward continuation of the Barnwell sand, but as no fossils have been obtained from the sands between Ocmulgee and Chattahoochee rivers, a positive correlation with the Barnwell sand of the Savannah drainage can not be made.

Perry, Houston County—Strata four and one-half miles south of Perry on the Perry-Elko public road, have been referred to the Claiborne group by Dr. Vaughan, who has furnished the following section and list of fossils.

"On the top of Mossy Hill, four and one-half miles south of Perry, *Pecten perplanus* and *Cytherea sobrina* were found in the chert. These fossils indicate that the northern slopes of Mossy Hill, from the summit of the hill to 45 feet below the summit, are covered by the Vicksburg formation.

Section down Mossy Hill along an old road leading to the northwest.

Oligocene.	
Vicksburg formation.	
7. Brownish or reddish soil with chert. Vicksburg fossils	20
Eocene	
Jackson formation ?	
6. Brownish soil, underlying material concealed	5
5. Gray clay	—
4. Mostly concealed	10
3. Gray clay	5
McBean formation.	
2. Limestone ledges with Claiborne fossils, list follows	5
1. Gray or buff clay	5
Total	50

Fossils from Mossy Hill.

Flabellum cuneiforme Lonsdale
Turbinolia pharetra Lea
Endopachys maclurii (Lea)
Turritella carinata Lea x
Mesalia vetusta (Conrad) x
Calyptrea aperta (Solander)
Dentallium thalloides Conrad
Nucula ovula Lea
Leda sp.
Leda sp.
Glycymeris idoneus (Conrad) ?
Phacoides alveatus (Conrad) x
Venericardia, 2 or 3 sp.
Cytherea sp.
Crassatellites sp.
Corbula oniscus Con. or wallesiana Harris
Corbula densata Conrad ?

Geologic horizon.—Claiborne. "x" not known from the Jackson."

A list of the species in a collection by Prof. McCallie from this locality, as furnished by Dr. Vaughan, is as follows:

Fossils from Perry-Elko public road, four and one-half miles south of Perry, Houston County.

Turbinolia pharetra Lea
Flabellum cuneiforme Lonsdale
Plejona petrosa (Conrad)
Levifusus trabeatus Conrad
Turritella carinata Lea x
Mesalia vetusta (Conrad) x
Dentalim thalloides Conrad
Nucula ovula Lea
Leda sp.
Glycymeris trigonella (Conrad) x
Pteria sp.
Phacoides alveatus (Conrad) x
Phacoides aff. clailbornensis (Conrad) x
Venericardia planicosta Lamarck
Venericardia alticostata (Conrad) x
Cytherea sp.
Crassatellites protextus (Conrad) x
Corbula oniscus Conrad x
Pteropsis lapidosa (Conrad)x

"x" not known from above the Claiborne. *Pteropsis lapidosa* is characteristic of the lower Claiborne.

According to Veatch the beds at this exposure consist mainly of drab, calcareous clay and thin layers of limestone, similar lithologically to the upper part of the Ross Hill section. Fossils were collected at an old quarry about 100 yards west of the public road, and four and one-half miles south of Perry. The strata forming the upper and lower part of the hill are concealed or poorly exposed. The following is a section by Veatch:

Section at quarry, four and one-half miles south of Perry.

		Feet.	In.
10.	Red, residual sand capping the top of the hill	—	
9.	Probably calcareous clay, about	40	
	Quarry exposure:		
8.	Calcareous clay	4	
7.	Limestone	0	10
6.	Drab, calcareous clay, contains calcite nodules	4	
5.	Limestone	1	6
4.	Clay	2	
3.	Limestone	1	
2.	Clay	2	6
1.	Poorly exposed, probably limestone and clay, about	20	

Both the clay and the limestone contain fossils. The fossils collected from this locality were from beds 5 to 8.

Dr. Vaughan submits the following note on Veatch's collections:

Besides material similar to that obtained by Prof. McCallie and myself, Mr. Veatch obtained specimens as follows:

Fossils from quarry, four and one-half miles south of Perry.

Mortonia sp.
Clypeaster sp.
Pecten perplanus Morton
Panopaea sp.

Lunulites distans (Lonsdale)
Idmonea n. sp. (Identified by Doctor Bassler, who states that it occurs at various Jackson localities, among them Rich Hill, Crawford County.)

"The paleontologic evidence indicates the presence at this locality of two horizons, viz.: a lower one of Claiborne age, from which Prof. McCallie and I collected, and from which Mr. Veatch also obtained material; and an upper horizon of Jackson age, from which Mr. Veatch obtained *Pecten perplanus* Morton and the species of *Idmonea* reported upon by Doctor Bassler. According to Mr. Veatch, as he could observe no lithologic differences in the section, he was unable to differentiate the exposure into two formations. The Barnwell seems to be absent."

This exposure of the Claiborne group described in the preceding paragraph, lies south of and at a higher elevation than the exposure of the Jackson formation at Ross Hill, three miles south of Perry (see page 301), indicating that at this locality, as Dr. Vaughan suggests, there has been either a fold or a fault in the strata or that the Claiborne here represents an erosion knob. The natural exposures in the neighboring areas are very poor, the contact between the higher formations and the Claiborne being concealed, so that it is impossible to make dip observations.

Flint River.—A small area of rock, exposed in the bluffs of Flint River in the southern part of Dooly and the eastern part of Sumter counties, belongs to the McBean formation.

The following is a section of a bluff near the old Danville ferry, located 16½ miles east of Americus, and one mile above the present ferry on the Americus-Drayton road. The bluff is on the right side of the river and is 50 feet high.

Section at old Danville Ferry, Flint River.

Pleistocene terrace deposit.	
6. Yellow, sandy loam, grading down into light mottled, sandy residual clay	7
Oligocene.	
Vicksburg formation.	
5. Sand, coarse to fine, variegated in color, with scattered fragments of flint; contains residual clay	23
Eocene.	
McBean formation.	
4. Soft, calcareous sand and sandy limestone . . .	8
3. Layer of indurated limestone containing *Pecten*, *Mortonia* and an oyster	2
2. Soft, glauconitic shell-marl	2
1. Compact, sandy limestone with rows of limestone concretions in places becoming an argillaceous marl with varying amounts of glauconites . .	8

Dr. Vaughan furnishes the following note:

"Dr. L. W. Stephenson made a collection at this locality and obtained the following fossils:

Fossils from old Danville Ferry.

Endopachys maclurii (Lea)	Phacoides alveatus (Conrad)
Mortonia lyelli (Conrad)	Phacoides cariniferus (Conrad)
Turritella carinata Lea	Miltha claibornensis (Conrad)
Calyptrea aperta (Sol.)	Tagelus ? sp.
Nucula ovula Lea	Corbula oniscus Conrad
Ostrea sellaeformis Conrad	Lunulites distans Lonsdale
Pecten lyelli Lea	

"It seems possible that two horizons may be represented in this collection, as *Ostrea sellaeformis* is not known to range upward to the upper Claiborne, and *Lunulites distans* is not known to range downward below the upper Claiborne. *Miltha claibornensis* is so far as at present known confined below the Gosport horizon of Alabama. A part of this section is positively the equivalent of the Lisbon horizon of Alabama, and that portion of Shell Bluff below the *Ostrea georgiana* bed."

Claiborne strata appear at Penny Bluff, 12 miles west of Vienna, and about one and one-half miles above old Danville Ferry.

Section at Penny Bluff.

	Feet.
Pleistocene (terrace sand)	
4. Gray incoherent sand	2 or 3
Eocene.	
McBean formation.	
3. Fossiliferous, thin-bedded sandstone; disintegrates into thin slabs which cover the face of the bluff and partly obscure the bed in the lower part	6
2. Greenish and drab sandy clay, contains calcareous nodules in places	8
1. White, semi-indurated calcareous sand. Has a pitted appearance and shows root-like or fucoid-like protuberances. Large *Ostrea georgiana* occur in this sand, as well as masses of comminuted shells	3

Fossils from Penny Bluff.

Turritella sp.	Venericardia planicosta Lamarck
Calyptrea aperta (Sol.)	Venericardia alticostata (Conrad)
Leda sp.	Cytherea
Arca rhomboidella Lea	Mactra
Ostrea georgiana Conrad	Corbula, etc.

Spencer[1] gives the following description of the Flint River Claiborne:

"Along the Flint River the Claiborne beds are well marked; commencing in the bluff just above the old Danville ferry. This bluff is over half a mile long and is composed of alternate layers of hard and soft sandy limestones, with beds as much as four feet thick, the softer beds having a more marly and clayey appearance. The rock is of a greenish or yellowish-white

[1]Report of progress: Geological Survey of Georgia, 1890-1891, pp. 51, 52.

color, its surface weathers into somewhat rough, but hardly jagged forms, which are so characteristic of certain beds of an overlying cherty formation. These Claiborne beds are well characterized by *Ostrea sellaeformis*, which are most abundant at the base of and in the harder ledges. In these bluffs the limestones rise to somewhat over 20 feet above the water and they are capped by an equal thickness of superficial sands and loams.

"Above and below the mouth of Ebenezer Creek, upon the left bank, excellent exposures occur in steep bluffs rising to 15 or 20 feet above high water. Here, the beds appear for considerable distances as quite horizontal, but again suddenly bend down at steep angles, which are followed by a return dip, thus producing undulations. The hard ledges stand out in bold relief, and the softer have a clay-like appearance. In some of the beds these harder layers form the larger proportions of the mass; in others but a small proportion.'

Chattahoochee River.—According to Langdon[1] the Claiborne extends from the mouth of Yantayabba Creek, Ala., to a point near Gordon, Ala., a distance approximately 25 miles air-line.

Langdon's description from the base upward follows:

(Base)		Feet.
57.	Plain buhrstone, rather sandy	40
58.	Light, yellowish green sand containing numbers of small *Ostrea sellaeformis*	45
59.	Buhrstone, supposed summit of the series . . .	55
60.	Greenish-yellow, calcareous clay with a few decomposed fossils and an occasional large *Ostrea sellaeformis*	12
61.	White, sandy limestone, with *Ostrea sellaeformis* in abundance, and pockets of large-sized shells. Makes capping ledge to island at mouth of Omussee Creek, where the bluff is about twenty feet high. This stratum is made up of alternate beds of hard and soft strata, all containing more or less *Ostrea sellaeformis*. The harder strata weather out into root-like shapes and are sometimes rather argillaceous. Many return dips occur in this stratum stringing it along the banks for many miles further than it would be normally. The dips are all steep both ways and many gaps in the succession are caused by the washing out of the soft strata. Owing to these gaps and return dips it is rather hard to estimate the thickness of the stratum with much accuracy. It dips below the surface of the river two miles below Gordon, Ala., and is last seen on the Georgia bank. At Gordon there is a very pronounced return dip, estimated at and not exceeding .	60
62.	The "Scutella bed" weathers so as to make it not possible to count up its thickness. It is literally full of fossils, mainly *Scutella lyelli* and *Pecten nuperus* with a few smaller and thicker *Scutella*. A bluff about 20 feet high occurs opposite the mouth of Sowhatchee Creek, Ga. . . . . 25 to	30

[1] Geology of the Coastal Plain of Alabama: Geol. Survey of Alabama, 1894, pp. 744, 745.

Nos. 57 to 61 belong to the Claiborne group and represent the McBean formation. No. 62 is suggestive of the Jackson and the probability of its being Jackson rather than Claiborne is mentioned by Langdon.[1]

The following section made by Dr. Stephenson from exposures along a road running east from the town of Fort Gaines reveals the character of the strata forming the upland above the second terrace plain; the base of the section is about 105 or 110 feet above the level of the river:

Section, Fort Gaines, above the Upper Terrace Plain.

	Feet.
Age ?	
8. Coarse, red, ferruginous pebbly sand. (Similar materials extend down over the hill for some distance—probably creep) about	15
McBean formation.	
7. Greenish sandy clays, and argillaceous sands, more or less weathered and mottled, about	40
6. Compact, fine, greenish-gray sandstone, with fossil prints. (Fossils collected) about	3
5. Pale green, fine loose sand, about	3
4. Compact, fine, greenish-gray sandstone, with fossil prints. (Fossils collected) about	3
3. Light green, compact, finely arenaceous clay about	7
2. Fine, green sandstone, about	3
1. Greenish clays and sands, more or less weathered and mottled, about	65
Total, about	140

Fossils collected from 55 to 65 feet below the top of the hill were identified by Dr. Vaughan as follows:

Pleiona sp.
Turritella sp.
Leda pharcida Dall ?
Venericardia planicosta Lam.
Miltha clairbornensis (Conrad)
Cytherea sp.
Solen lisbonensis Aldrich ?

On the basis of these fossils the strata Nos. 1 to 7 are referred to the McBean formation. The age of bed No. 8 in the section is in doubt. Similar red sand which contains a bed of *Ostrea divaricata* was observed southward.

The McBean formation also appears in Chattahoochee River bluff at Fort Gaines. The base of the Claiborne is 50 to 55 feet above mean stages of the river. The rock is a drab, laminated clay or clay stone, and gray, fossiliferous sand. For sections of the bluff and fossils see pages 231-233. The fossils *Ostrea sellaeformis* Conrad and *Pecten lyelli* Lea were obtained about 40 feet below the top of the section, or 12 to 14 feet above the base of the McBean formation.

There is an interesting locality at the mouth of Omussee Creek, a

[1]Op cit., p. 383.

short distance below Columbia, Ala. A small, triangular island capped with brown marl and covered with specimens of a large, saddle-shaped oyster, *Ostrea sellaeformis,* lies adjacent to the creek's mouth. The capping rock is a brown, compact marl, granular in appearance, and very similar to much of the Claiborne marl on Savannah River. It is composed of fine angular quartz sand and white or yellow clay cemented with calcium carbonate; there are small scattered grains of glauconite and phosphate. This bed is three and one-half feet thick and forms a projecting ledge over the lower bed. On account of the high water in the river only seven feet of the lower bed was exposed when visited by the writers. The bed is ash-colored or bluish, soft and contains more clay and less sand and calcium carbonate than the capping rock. A hard, siliceous limestone overlain by red and vari-colored sand was observed a short distance up the creek from the island. A similar limestone appears near the wagon bridge over the river, on the Georgia side.

A good collection of fossils was obtained from a sandy fullers earth-like clay, two and one-half miles east of Fort Gaines.

Section of hill along public road to Edison, two and one-half miles east of Fort Gaines.

	Feet.
Age ?	
8. At the top of the hill, structureless, deep red sand, at surface; light colored and yellowish in fresh exposures	30
McBean formation.	
7. Greenish, laminated clay	2
6. Sand	3
5. Drab, laminated clay (fossils collected) and aluminous soft sandstone; black clay layers at the base; fragments of stems and leaves	15
4. Clay and sand, about	5
3. Black, sulphurous, sandy clay	4
2. Aluminous sandstone, prints or fossils	2½
1. Concealed to level of creek	4

Fossils collected from No. 5, and identified by Dr. Vaughan, are as follows:

Fossils from layer No. 5 in preceding section.

Plejona petrosa (Conrad)
Plejona sayana (Conrad)
Leda
Barbatia cuculloides (Conrad)
Barbatia rhomboidella (Lea)
Anomia
Leda pharcida Dall.
Venericardia sp.
Cytherea discoidalis Conrad
Metis raveneli (Conrad)
Tellina mooreana Gabb
Mactra
Pteropsis lapidosa Conrad

"This represents the lower portion of the Alabama Claiborne." T. W. V.

There seems to be a lithologic gradation from the upper red sand to the lower sandy clay. The tops of the hills are about 300 feet above the Chattahoochee River. At Mount Vernon church, four and one-half miles east of Fort Gaines, an erosion remnant of orbitoidal chert was found overlying the Claiborne red sand. At Fort Gaines the thickness of the Claiborne group must be nearly 200 feet.

Near Neves mill, on the south side of Colomokee Creek, seven miles south of Fort Gaines, a thin, unconsolidated bed of small *Ostrea divaricata* shells occur in the upper red sand of the Claiborne group and laminated drab and black clays form the basal part of the section. Still farther south the basal clays of the Claiborne group become more calcareous and are partly replaced by limestone and marl.

At Grimsley's mill, 13 miles south of Fort Gaines and about two miles east of the Chattahoochee River, characteristic lower Claiborne fossils were collected. The generalized section here is as follows:

Generalized section at Grimley's Mill.

	Feet.
Age?	
3. Red sand	50 to 75
Eocene.	
McBean formation.	
2. Interbedded clayey marl, and bluish or drab fullers earth-like clay; *Ostrea divaricata, Pteropsis lapidosa, Calyptrea aperta*	15 to 20
1. Soft, argillaceous marl and limestone	10

A marl exposure was visited on the farm of W. C. Hutchins, on Chattahoochee River, nine miles west of Blakely. From a number of exposures it is inferred that the beds underlying the first terrace plain which lies 35 or 40 feet above the river, are bluish and ash-colored sandy marls and clays and beds of sandy limestone, overlain by Pleistocene sands and clays. Red sand containing thin beds of broken shells appears in the scarp of the upland.

The following is the columnar section of the Claiborne group at this locality:

Section on farm of W. C. Hutchins.

	Feet.
10. Red sand, often highly ferruginous, appears on the higher land	?
9. Thin bed of comminuted shells, *O. divaricata*	1
8. Red sand	12
7. Unconsolidated bed of sand; layer of loose shells, *O. divaricata*	2
6. Red quartz sand	12
5. Bluish argillaceous sand	12

4. Sandy limestone		
3. Bluish and drab sandy laminated clay		
2. Marl bed, composed of shells, teeth, bones, in a matrix of calcareous, glauconitic clay and sand .		40
1. Hard sandy limestone		

Strata of the character of that from 1 to 4 underlie the first terrace plain and have a total thickness of about 40 feet. The strata Nos. 5 to 9 were observed along the public road east from Mr. W. C. Hutchins' residence.

Other localities.—Eastward from Fort Gaines but few fossiliferous localities have been found, and the strata mapped as Claiborne were determined to be such, mainly on the grounds of their lithologic character, stratigraphic position between known Vicksburg and Wilcox strata, and the presence of erosion unconformities separating the formation from the two formations mentioned.

The Claiborne red sands at Fort Gaines were traced northeastward to Cuthbert, where there is a thickness of only 50 or 75 feet. Unconformable relations with the overlying Vicksburg formation were observed in the cuts of the Central of Georgia Railway, two miles west of Cuthbert, and an unconformity believed to separate it from the Wilcox formation was found in the cuts three miles west. At the old quarries one mile northwest, there is a soft aluminous sandstone and laminated drab clay, overlain by fine red sand, probably Claiborne. The soft sandstone contains a few fossils; Dr. Vaughan identified *Turritella* probably *carinata.*

The fine variegated sand which is exposed in the vicinity of Shellman is referred to the Claiborne group. Flint fragments of the Vicksburg formation imbedded in sandy clay, quite different from the underlying Claiborne strata, are found on the higher land, while a few miles northward from Shellman irregular contacts with the underlying Wilcox formation were found. The Claiborne sand contains very little clay, but in a few places contains beds of brown or black limonitic sandstone. This soft sandstone was used in the abutments of the Central of Georgia Railway trestle over Ichawaynochaway Creek, two miles east of Shellman. No fossils were found, The thickness in the vicinity of Shellman is probably 100 to 150 feet.

At Cordray Mill, on Ichawaynochaway Creek, 12 miles east of Edison, a calcareous, aluminous sand, slightly indurated, occurs in the bed of the creek. This material contains a few clay fossil casts and fragments of an oyster shell, and probably belongs to the McBean formation. At Bateman "Hammock," one and one-half miles below the mill, there is an exposure of about one foot of clayey sand and sandstone which contains *Ostrea divaricata.* Above this bed there are three feet of hard, sandy limestone, containing a species

of *Pecten,* Bryozoa, and fragments of a large oyster. There is some probability that this limestone bed belongs to the Jackson formation.

At Parrott, Terrell County, the high ridge followed by the Seaboard Air Line Railway is capped with red sandy clay containing residual fragments from the Vicksburg formation, but both to the east and west on the lower land, there are red and yellow incoherent sands quite different from the Vicksburg materials, and probably referable to the Claiborne groups. At Walker's Mill on Mossy Creek about one and a half miles southeast of Parrott, there is an exposure of aluminous sandstone, quartzite, and drab claystone overlain by red sand, similar to the section of the Claiborne group at Fort Gaines.

What is probably the McBean formation was found in a bluff of Kinchafoonee Creek, near Hall's Bridge, four miles southwest of Smithville. The rock is a hard, aluminous, calcareous quartzite, and white, flaggy sandstone similar to that at Penny Bluff, Flint River. The fossils are not well perserved but are suggestive of the Claiborne. About six feet of hard rock is exposed and is overlain by red sand.

The Claiborne group in the vicinity of Americus, and south of Andersonville, consists principally of quartz sand, in places highly ferruginous. Unconformities with the overlying Vicksburg formation may be seen in railway and road cuttings in and near the city of Americus. Bluish, sandy clay and sandy, glauconitic marl and sandstone, doubtless in the Claiborne group, are encountered in well borings at Americus.

CONGAREE CLAY MEMBER OF McBEAN FORMATION

The term Congaree, as has been stated, is adopted from South Carolina. Sloan[1] defines the Congaree as follows:

"The Congaree phase is abundantly exhibited in the western Tertiary division along a curved line extending by Aiken, Sandy Run (on the Congaree), Wedgefield, and thence down the eastern side of Santee River; it is also characteristically exhibited along the belt extending from Wedgefield towards the eastern division north of the Carolinian ridge. East of the latter the Congaree phase is probably exhibited in thin shales interlaminated with sands along the western bluffs of Peedee River."

Again quoting Sloan:[2]

"The Congaree phase exhibits its littoral line along Hollow Creek near Savannah River and proceeds with occasional tongues extended in conformity with the shore-line indicated for the Tertiary. The main line proceeds from McBean Creek Valley, Ga., by Beech Island, Aiken, Perry, Horsey's Bridge, and Gaston, to the vicinity of Congaree Bluff."

[1]Catalogue of mineral localities of South Carolina: Geol. Survey of South Carolina, p. 454.
[2]Op. cit., p. 455.

Lithologic descriptions of the Congaree near Gaston, S. C., and Congaree Creek are given by Sloan.[1]

The Congaree as described in South Carolina and the member to which this term is applied in Georgia are regarded as equivalent. Both lies at the base of the Claiborne group and have a close lithological similarity. The clays of this member in Georgia rest directly upon the Lower Cretaceous, and are separated from it by conspicuous erosion unconformities of regional extent; striking differences in lithologic character and the presence of fossils in the former afford an easy means of distinguishing between the two.

Faunally the Congaree clay member does not seem to differ from the lower faunal horizon of the marl of the McBean formation. It seems probable that the clays represent a shoreward phase, or that the Congaree clay member becomes more calcareous southward and gradually merges into the marl. In most of the sections studied, the clay and fullers earth seem to pass by gradation upward into the Barnwell sand. There are, however, some unconformities between the two and abrupt changes in the character of the strata; these may be of only local significance, such as might take place in a shallow water deposition.

The fullers earth is drab or gray, often appearing olive-green when moist, fine-grained, thinly-bedded, and minutely jointed. It is generally sandy and contains small sand lenses and pockets, and has thin, micaceous sand partings; the earth is soft, unctuous, and breaks with a smooth, conchoidal fracture. It possesses a low specific gravity and peculiar physical properties,—thin pieces of the dry earth are light enough to float on water; it is highly porous, and adheres strongly to the tongue. In a few places the Congaree clay member contains a large amount of disseminated, lignitic matter, and thin beds of lignite, as at the lignite pit, three miles south of Grovetown, which will be subsequently described. Thin-bedded shale-like, aluminous sandstones and dense, vitreous quartzites were observed near the base of the member at Hephzibah, Wrens, Gibson, Chalker, and other localities. At a number of localities greenish or drab, stiff, or tough clays, showing little or no lamination and attaining a thickness of 80 or 100 feet, lie in contact with the Lower Cretaceous. In places the materials consist of alternating layers, a few inches thick, of clay and vari-colored sand.

The clay and fullers earth beds reach a thickness of at least 100 feet. This member contains abundant fossil remains in a few places, though on the whole, it is not so fossiliferous as the marls. The animal remains are mainly molluscan casts, although the clay also con-

[1]Op. cit., pp. 346, 347.

tains thin marly layers in which shells occur in quantity, and in which fish teeth and fragments of bones are found. Plant localities have been discovered at Grovetown, Hephzibah in Richmond County, and 10 miles south of Macon in Bibb County. This member is not paleontologically distinct from the McBean formation.

There are numerous outcrops of the Congaree clay member from Grovetown southwestward along the Fall Line to Bibb and Twiggs counties. It is confined to the northern part of the area of the outcrop of the McBean formation, but no sharp line separating the member either from the marls of the McBean formation to the south or the overlying Barnwell sand can be drawn. The most prominent and typical exposures are at Grovetown, Harlem, Gibson, Gordon, Roberts, and Pikes Peak in Twiggs County. The clays have had no marked influence on the soil and vegetation, and outcrops appear mainly in gullies and ravines where the overlying red sands have been eroded.

LOCAL DETAILS

COLUMBIA COUNTY

Grovetown.—Grovetown is located on the Georgia Railroad 15 miles west of Augusta. Fullers earth and clay of the Congaree clay member of the McBean formation are exposed at a number of places in this vicinity.

Section at the old fullers earth mine.

Eocene.	
Barnwell sand.	Feet.
3. Red, pebbly sand	5+
McBean formation (Congaree clay member).	
2. Fullers earth, gray or drab, laminated; contains bits of wood and has fine sand partings and pockets	10-12
Lower Cretaceous	
1. White clay, full thickness not exposed	4+

The fullers earth is also exposed in the cut at the railroad station, where there is four feet of fullers earth overlain by 10 feet of red, pebbly sand. It is probable that both the clay and sand belong to the Claiborne group. There is apparently a very slight unconformity between the sand and clay. In the first cut south of the station there is an exposure of 20 feet of sand which evidently overlies the fullers earth, and belongs to the Barnwell sand.

About one-quarter mile west of Forest, casts of fossils are abundant, in an aluminous sandstone. Underneath the fossil layer is a thin, shaly bed resembling the fullers earth at Grovetown, and at a still lower level there is a prominent exposure of arkose or kaolinic

sandstone of Lower Cretaceous age. This locality has been visited by Prof. G. D. Harris[1] of Cornell University, who noted oyster fragments and a species of *Modiola,* but no definite horizon for the strata was given.

About three-quarters of a mile west of Forest on the old Fiske place there is a yellow, ochreous, shaly earth, which contains casts of fossils, and is evidently the equivalent of the Grovetown fullers earth, and belongs to the Congaree clay member. This is overlain by red, pebbly sands.

In a gully on the Phinizy land, on the Augusta and Wrightsboro public road, about one mile east of Grovetown, a laminated fullers earth fills an erosion hollow in the Cretaceous. The locality is notable for the clear-cut exposure of the unconformable relations of the two formations. The fullers earth contains impressions of leaves, stems, and palms, the determination of which may be of considerable stratigraphic interest.

The fossils recorded in the following list were determined by Dr. Vaughan from a collection made by Prof. McCallie, in the Fiske clay pit:

Fossils from Fiskes clay pit.

Nucula magnifica Conrad
Nucula ovula Lea
Leda 2 sp.
Balanus sp.
Turbinella (Psilocochlis) mccalliei Dall
Ostrea
Modiolus texanus Gabb
Calyptrea aperta (Solander)

Lignite and lignitic clay belonging to the Claiborne group appear at the lignite pit of the Georgia Lignite Mining Company, three miles south of Grovetown.

Section of Lignite pit.

		Feet.
Barnwell sand.		
12.	Beginning at top. Grayish or brownish incoherent sand	3 or 4
11.	Red, coarse, quartz sand	8 to 10
10.	Laminated clay layer	2
9.	Coarse, angular, yellow quartz sand; contains limonite fragments, in places small gravel	15
8.	Red, brown, and purplish crossbedded sand; scattered small pebbles; some thin clay layers a few inches thick; uneven contact between this sand and the underlying lignitic clay	35
McBean formation (Congaree clay member).		
7.	Pink and white, plastic clay, partly removed by erosion	1
6.	Lignite	2
5.	Drab, clay, some lignitic material	2

[1]Bull. Amer. Paleontology No. 6, Dec. 8, 1902, p. 7.

		Feet.
4.	Lignite; large lignitized logs	4
3.	Drab clay	1
2.	Lignite	1
1.	Lignitic clay	2

The lignite and lignitic clays were penetrated in a nearby shaft, and were found to have a thickness (reported) of 15 feet. Coarse, quartz sand conatining white clay, evidently Lower Cretaceous, unlerlies the lignitic beds. The similarity of the sections leaves no doubt that the lignite and lignitic clay are the equivalent of the fullers earth at Grovetown. The sand in the section represents a shoreward aspect of the Barnwell sand.

This locality was described by Lewis[1] in 1880 who regarded the formation as contemporaneous with the Brandon formation of Vermont and Pennsylvania. As Professor Knowlton has, from a study of the fossil flora at Brandon, concluded that the age of that deposit is probably Miocene, Lewis's correlation is known to be erroneous.

Harlem.—The succession of beds and the character of the strata in this vicinity are essentially the same as at Grovetown and vicinity.

The following section is revealed at the plant of the Georgia Vitrified Brick & Clay Company, one and a half miles east of Harlem:

Section at plant of Georgia Vitrified Brick and Clay Company.

	Feet.
Eocene.	
Barnwell sand.	
7. Red and yellow, highly ferruginous sand; contains siliceous limonite fragments, covered with a thin veneer of gray sand	25
6. Yellow sand, pebbly; fragments of silicified wood	8
McBean formation (Congaree clay member)	
5. Yellow and white sandy clay	5
4. White, massive, sandy clay; contains bits of carbonized leaves and wood	7
3. Black, carbonaceous, jointed clay	4
2. Concealed, a few feet	?
Lower Cretaceous.	
1. Massive, indurated, white clay, having the lithologic aspect of the Cretaceous white clay	12

Section at Phillip's Falls, one and one-half miles southwest of Harlem.

	Feet.
Barnwell sand.	
5. At top of section, red sand	10
McBean formation (Congaree clay member).	
4. Bluish and gray, laminated fullers earth, fragments of plant remains . . . 20 to	30
3. Sandy clay, evidence of fossil plants but no well preserved forms were found	3

[1]Clark, W. B., Bull. U. S. Geol. Survey No. 83, p. 94.

2. Massive bed of gray to bluish gray indurated clay; not laminated	10
1. Coarse, quartz sand, containing large chunks of white clay	10

A small exposure of lignite and dark lignitic clay also occurs along a small stream on the south side of the railroad, on the old Lucky place, about three-quarters of a mile from the station at Harlem. This is overlain by 12 feet or more of fullers earth and red and yellow limonitic sand.

JEFFERSON COUNTY

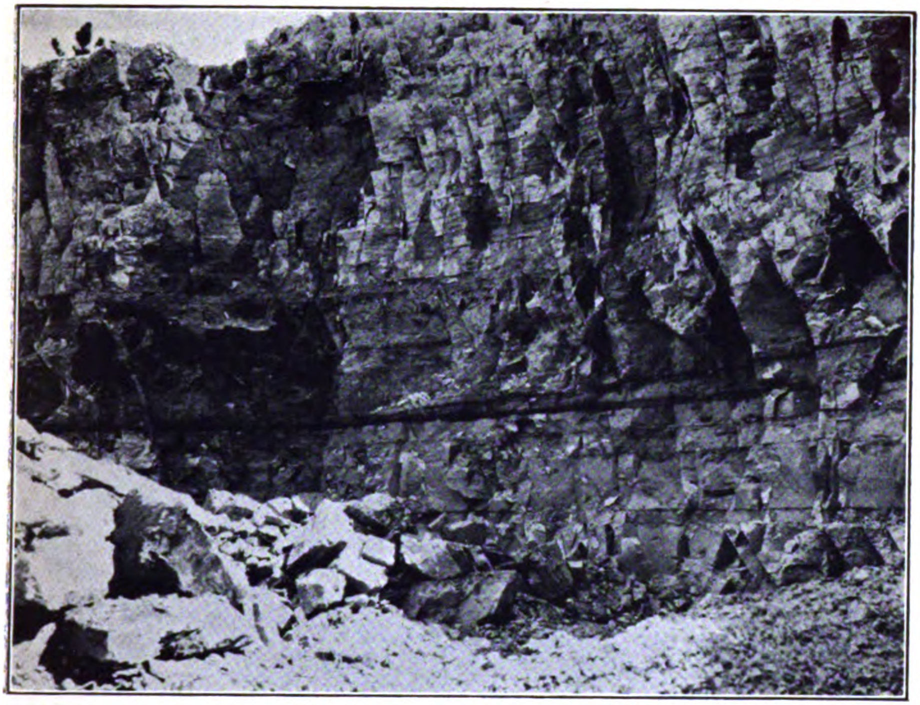
Wrens.—A peculiar claystone, together with a shaly, aluminous sandstone, was found at R. R. Hatcher's mill on Reedy Creek, five miles north of Wrens. The shaly sandstone contains fragments of lignitized wood and stem and leaf impressions. The hard clay is bluish-white in color, compact, breaks with a conchoidal or angular fracture, and is almost entirely free from sand. A chemical analysis shows the proportion of silica (65.21 per cent.) to alumina (21.62 per cent.) to be much greater than that of the hard white clays of the Cretaceous. The clays here are overlain by red, pebbly sand representing the Barnwell sand.

At Patterson's Bridge on Briar Creek, six miles north of Matthews, there is 10 feet of sandy, laminated fullers earth, with which is associated some silicified clay similar to that at Hatcher's Mill. A short distance south of the bridge there is an outcrop of quartzite containing fossils. The exact relations of this quartzite to the fullers earth could not be determined, but it is inferred that it lies above the fullers earth.

At Wrens old mill, two miles south of Wrens, about 25 feet of sandstone and quartzite appears. This rock contains oyster shells that could not be specifically identified. On the road between Wrens and Matthews outcrops of vitreous quartzite and laminated clays were noted. These outcrops probably belong to the Congaree clay member.

GLASCOCK COUNTY

Gibson.—There are a number of good exposures of the Claiborne group in the vicinity of Gibson. The group lies unconformably upon the Lower Cretaceous and is divisible into two formations, as indicated in the following section:



A. FULLERS EARTH IN CONGAREE CLAY MEMBER OF McBEAN FORMATION, PIT OF GENERAL REDUCTION COMPANY, TWELVE MILES SOUTHEAST OF MACON, IN TWIGGS COUNTY.

B. CUT OF MACON, DUBLIN & SAVANNAH RAILROAD, PIKES PEAK STATION, TWIGGS COUNTY, SHOWING CONGAREE CLAY MEMBER OF McBEAN FORMATION.

Section at the J. Newsome property, three miles east of Gibson.

Eocene.	
Barnwell sand.	
6. Red, crossbedded sand capping the hill	30
McBean formation (Congaree clay member).	
5. Massive, drab, and greenish clay	20
4. Soft, fossiliferous limestone	5
3. Calcareous sandy clay	5
2. Sand, containing large pellets of white clay	15
(Unconformity)	
Lower Cretaceous.	
1. White clay or kaolin	6+

An instructive exposure appears along the Gibson-Mitchell road at Jumping Gully Creek, one mile west of Gibson.

Section at Jumping Gully Creek.

Eocene.	
Barnwell sand.	Feet.
5. At the top of the hill, fine, red, argillaceous sand . . .	10+
McBean formation (Congaree clay member).	
4. Gray laminated clay, somewhat in the nature of fullers earth	10
3. Laminated, sandy, clay, containing thin limonitic, crusts; very fossiliferous. Fills narrow "V" shaped erosion gullies in the underlying white clay	3
Lower Cretaceous.	
2. White clay	10
1. Talus to level of creek	

From bed No. 3 the Claiborne fossils, *Flabellum cuneiforme, Turritella carinata,* and *Mesalia vetusta* have been collected.

Prof. McCallie collected fossils at the English plantation, one and one-half miles north of Gibson. These have been identified by Dr. Vaughan, who furnishes the following list and annotation:

Fossils from the English plantation.

Flabellum cuneiforme Lonsdale
Endopachys maclurii (Lea)
Mazzalina inaurata Conrad
Turritella carinata
Pecten wilcoxii Dall ?
Pteria sp. (the internal mould of a rather large species)
Venericardia planicosta Lamarck
Venericardia alticostata (Conrad)
Lucina sp.
Panopaea aff. oblonga Conrad
Cytherea sp.

"The matrix is a light gray, in some instances blotched yellow, indurated sandstone, some pieces considerably silicified.

"The fauna is Clairbornian but whether upper or lower could not be determined from the fossils submitted."

Good exposures appear in road cuttings and gullies south and southwest of Gibson.

Section at Tompkins Ford on Grange road, four miles south of Gibson.

Eocene.	
Barnwell sand.	Feet.
6. At top of hill, red sand	10
5. Sandstone or quartzite containing fossils	4
4. Red sand, fine-grained, and argillaceous	15
McBean formation (Congaree clay member).	
3. Massive, stiff, tenacious, greenish or drab clay; massive surface aspect may be due to weathering	30
Lower Cretaceous.	
2. White, massive, semi-indurated clay, distinguished from that above by its much greater purity	15
1. Soft clay and sand conglomerate	

WASHINGTON COUNTY

Sandersville.—Limestone occurs near Sandersville, which will be discussed later. A considerable thickness of clay and sand is exposed north and west of Sandersville, while at Sandersville and southward limestone and calcareous strata occur.

The following section was observed along the upper Milledgeville road on the descent to Keg Creek, six miles west of Sandersville.

Section six miles west of Sandersville.

Eocene.	Feet.
Barnwell sand.	
4. At top of the hill, bright, red sand, hardened at the surface by iron oxide cement. Fresh exposures show yellow and red, coarse, unconsolidated sand	60
3. Red sand, containing gray, waxy, clay laminae. The clay is in layers often not more than one-half or one inch thick	20
McBean formation (Congaree clay member.)	
2. Gray, greenish or drab clay, tough and waxy where weathered; fresh exposure laminated in the nature of fullers earth; apparent gradation between this and the overlying sand	45
Lower Cretaceous.	
1. Hard, massive, white fireclay	16

Sand and clay, which can be correlated with that in the foregoing section, appears in a deep gully to the north of the Milledgeville road, four and one-half miles west of Sandersville.

Section four and one-half miles west of Sandersville.

Eocene.	Feet.
Barnwell sand.	
5. Red sand at top of gully	15
4. Lighter colored sand	10
McBean formation (Congaree clay member).	
3. Laminated, fullers earth-like clay, becomes sandy at top, and there is an apparent gradation between 3 and 4	20

2. Marl layer, a fossiliferous, bluish mud, and in places a bed of comminuted shells (Claiborne fossils)	3
1. Bluish mudstone	15

At the Carter Mill site, four and one-half miles north of Sandersville, the following succession of beds was observed:

Section five and one-half miles north of Sandersville.

Eocene.
  Barnwell sand.
    4. Red sand, contains a siliceous, fossiliferous rock . . .
    3. Coarse quartz pebble conglomerate, a few feet in thickness . . . .
  McBean formation (Congaree clay member).
    2. Laminated clay and argillaceous sand, the latter probably reworked Cretaceous . . . .
Lower Cretaceous.
    1. Massive, white, fire clay . . . .

One mile north of this locality the following succession was observed in the hill on the public road:

Section six and one-half miles north of Sandersville.

	Feet.
Eocene.	
5. Red sand, in places large, well rounded quartz pebbles	40 to 50
4. Red sand, thin beds of greenish laminated clay . .	
3, Coarse red sand	
Cretaceous.	
2. White massive fire clay	10+
1. Typical Cretaceous sand	

In a well at Thena, eight miles west of Warthen, 50 feet of laminated, shaly clay, in the nature of fullers earth and containing casts of fossils, was encountered in a well. The underlying Cretaceous is exposed in the valley of Keg Creek a short distance east, and the upland is covered with the red Barnwell sand and gray surficial sand.

A section of a hill on the road to Hebron, seven miles southwest of Sandersville shows:

Section seven miles southwest of Sandersville.

	Feet.
Eocene.	
Barnwell sand.	
3. At the top, fine red sand apparently conformable on No. 2	10
McBean formation (Congaree clay member).	
2. Greenish and drab, massive and laminated clay	80
Lower Cretaceous.	
1. White clay	4

There appears to be a gradation between 2 and 3 where the sand is superimposed; both clay and sand are in contact with the Cretaceous in exposures west of this locality.

Chalker.—Exposures along the public road, one-half mile south of Chalker, show at the top of the hill, 30 feet of fine, red sand, becoming more argillaceous at the base, and 50 feet of laminated, sandy clay (Congaree clay member) overlying white and yellow sands of the Cretaceous.

In the railroad cut, one mile south of Chalker, a thin-bedded, aluminous sandstone two or three feet thick, at the base of the Tertiary, overlies a white clay bed of the Cretaceous.

From a cut two miles southwest of Chalker, Prof. McCallie collected fossils from a sandstone that directly overlies white clay of the Cretaceous. These fossils have been identified by Dr. Vaughan, who furnishes the following list:

Fossils from two miles southeast of Chalker.

Flabellum cuneiforme Lonsdale	Mesalia vetusta (Conrad)
Cucullaearca cuculloides (Conrad)	Venericardia
Cerithium ,2 sp. both apparently new	Ostrea georgiana Conrad-?
	Cytherea
Turritella carinata Lea	Corbula alabamiensis Lea

WILKINSON COUNTY

Gordon.—A number of good exposures of Tertiary and Cretaceous beds occur in this vicinity. A section made along the public road on the Ezell or W. S. Smith place, one and one-half miles south of Gordon shows:

Section one and one-half miles south of Gordon.

	Feet.
Eocene.	
Barnwell sand.	
5. At the top of the hill, dark, red sand with small quartz pebbles	40
4. Red, orange, and brown sand, contains thin, greenish clay layers about an inch in thickness	15
McBean formation (Congaree clay member).	
3. Greenish or drab clay, containing casts of fossils; in places white, siliceous concretions. The clay is massive, where weathered, but in fresh exposures is bedded and resembles fullers earth	50
2. Bluish sandy clay with red splotches, due to weathering	10
Lower Cretaceous.	
1. White, massive-bedded clay	12

The same general succession prevails southward in numerous gullies and road cuts. At a few localities the red sands at the surface seem to overlie the greenish and drab clays unconformably, but most of these are not true erosion unconformities but are due to "creep" of the red sands down hill slopes.

At Ball's Church, about eight miles south of Gordon, a deeply eroded gully on a hillside shows:

Section in gully at Ball's Church.

Eocene.	
Barnwell sand.	Feet.
3. Top of hill, dark, red sand. Becomes more argillaceous at the base	70
McBean formation (Congaree clay member).	
2. Drab, laminated clay layers, with sand partings. Clay porous, low specific gravity, and in the nature of fullers earth	50
Lower Cretaceous.	
1. Massive white clay	5+

Prof. McCallie has furnished a description of a section two miles west of Gordon, on the Gordon-Macon public road, as follows:

Section two miles west of Gordon on public road.

Eocene.	
Barnwell sand.	Feet.
9. Stratified, red, sandy clays, upper part massive	10
7. Yellowish, stratified sands	6
6. Thin-bedded, tough, drab colored clays	10
5. Thin-bedded, reddish sands with clay partings	3
McBean formation (Congaree clay member)	
4. Fullers earth (?) with fossils	15
3. Fine, orange-colored sand	4
(Unconformity)	
Lower Cretaceous.	
2. White clay (kaolin) massive	4
1. Massive, micaceous, sandy clay, base of section	

Fossils from stratum No. 4 were identified by Dr. Vaughan.

Fossils from Stratum No. 4.[1]

Platytrochus stokesi (Lea)
Plejona petrosa (Conrad)
Nucula ovulia Lea
Leda bella
Leda sp. ?
Leda sp.
Tagelus sp.
Diplodonta (Sphraerella) aff. inflata Lea
Miltha aff. claibornensis (Con.)
Cytherea sp.

Lewiston.—Ladd[2] gives the following section in a clay pit at Lewiston:

Section in clay pit at Lewiston.

Eocene.	
McBean formation (Congaree clay member)	Feet.
5. Red and yellow, clayey sand, with seams of laminated clay; also thin seams of brown iron ore, containing many coarse pebbles	6

[1]These fossils do not furnish sufficiently definite information to determine the horizon within the Claiborne.—T. W. V.
[2]Bull. Geol. Survey of Georgia No. 6-A, p. 113.

		Feet.
	4. Irregular siliceous beds, resembling quartzite, and containing drusy quartz cavities and many fragments of shells	4
	3. White sand, free from iron stain, cross-bedded in places, containing mica and kaolin, and also nodules or fragments of white clay, in the upper surfaces of which are sharply outlined pear-shaped cavities, each filled with a yellowish clay. These cavities vary in diameter from one-quarter to one inch	7
Lower Cretaceous.		
	2. White, gritless clay, or kaolin	2
	1. White sand	2

The white clay is probably Cretaceous; characteristic Claiborne fossils occur in the quarzite at this locality.

Prof. McCallie has collected fossils on the farm of J. W. Huckabee, one and one-half miles west of Lewiston, which have been identified by Dr. Vaughan as follows:

Fossils from farm of J. W. Huckabee.

"Endopachys maclurii (Lea)
Turbinella sp.
Turritella carinata Lea
Mesalia vetusta (Conrad)
Nucula ovula Lea
Venericardia planicosta Lamarck
Crassatellites protextus (Conrad)
Corbula oniscus Conrad
Corbula alabamiensis Lea

"Although this is clearly a Claiborne fauna the precise horizon within the Claiborne is indefinite."

TWIGGS COUNTY

Pikes Peak station.—Three-quarters of a mile west of Pike Peaks Station, in the Dry Branch region, the formation is more argillaceous than in the foregoing sections, being represented by a heavy bed of fullers earth. Fossils identified from this locality are *Nucula* aff. *ovula, Ostrea georgiana, Crassatelliles protextus.*

Section at General Reduction Company's fullers earth mine.

		Feet.
Barnwell sand.		
	3. Red and white sand	10
	2. Greenish and drab, waxy and tough, clay, only laminated, locally known as "gum"	6 to 10
McBean formation (Congaree clay member).		
	1. Heavy-bedded fullers earth	15

No unconformities occur in this pit. In an abandoned pit a similar succession appears:

		Feet.
Barnwell sand.		
	3. Red and white sand, contains thin layers of fossiliferous sandstone	15
	2. Greenish, waxy, faintly laminated clay, "gum" from 2 or 3 to 10 or 12 feet in thickness	
	(Apparent unconformity)	
McBean formation (Congaree clay member).		
	1. Heavy-bedded fullers earth	10 to 25

The fullers earth is a drab or olive color when moist, becoming almost white when dry. The beds or layers are from a few inches to two or three feet in thickness, and are separated by fine, micaceous sandy partings. The fullers earth itself is sandy and contains circular or lenticular pockets of gray sand reaching two or three inches in their greatest dimensions. The earth is soft, unctuous, very porous, and of low specific gravity; it is minutely jointed and the joint cracks are filled with limonitic coatings or show thin black scales of manganese dioxide.

The following section appears in the railroad cut at the overhead wagon bridge a short distance southeast of the fullers earth mill:

Section in railroad cut near Pikes Peak Station.

	Feet.	In.
Barnwell sand.		
8. Red sand	4	
7. Red and white sand	6	
6. Greenish clay	5	
5. Drab fullers earth clay, thin layered sand partings	8	
4. Yellow sand	0	2
McBean formation (Congaree clay member.)		
3. Heavy bedded, jointed earth	6	
2. Gray, fossiliferous sand	4	
1. Talus	4	

In the first cut beyond the overhead bridge and near Pikes Peak station, a striking unconformity appears between red sand and fullers earth-like clay. The cut shows 10 feet of fine, red sand mantling 25 feet of bedded and jointed fullers earth and clay. The full significance of this unconformity is not known; however, it is believed that the red sand belongs to the Claiborne group.

JONES COUNTY

Roberts Station.—Bluish, fossiliferous mud and thinbedded clay in the nature of fullers earth occur in a cut on the Georgia Railroad one mile east of Roberts. This locality was studied by Prof. G. D. Harris,[1] who referred the strata to the "Woods Bluff" (Bashi) beds of the "Lignitic" (Wilcox). Dr. Vaughan has identified a large number of species from this locality, a greater number than is

[1]American Paleontology, Bull. No. 16, 1902, p. 4.

given by Professor Harris, which shows the Claiborne (not Wilcox) age of the beds. There is also lithologic similarity to the Claiborne sections at other nearby localities. This clay represents the Congaree clay member of the McBean formation, and the sand probably the Barnwell sand of the Claiborne group.

Section in cut one mile east of Roberts.

Eocene	
Barnwell sand (?)	Feet.
6. Beginning at top, loose red sand, contains a few scattered quartz pebbles, no fossils observed .	8 to 10
McBean formation (Congaree clay member.)	
5. Greenish and drab laminated sandy clay, porous and of low specific gravity	12
4. Laminated, sandy clay containing white calcareous nodules and casts of fossils	8
3. Bluish, fosiliferous mud	8
Crystalline basement rock.	
2. Concealed a few feet	?
1. Crystaline, igneous rock	—

The igneous rock does not appear in the deep cut, but outcrops in the next cut east. There is no evidence of an unconformity between the red sand and the clay. The red sand, No. 6, was traced north from the cut as far as Slocumb on the Central of Georgia Railway. It contains fragmentary beds of quartzite in which are comminuted shells, and since these have no appearance of having been transported there is little doubt about its Eocene age. In the cut about one-quarter of a mile east of the "shale" cut, the red sand, (at the base interbedded sand and clay) is in contact with a decomposed granite and a diabase dike, the latter having a width of about 100 feet. There is no evidence that the dike was intruded in the Tertiary strata.

In the first cut west of Roberts, red sand, containing small fossiliferous, quartzite fragments, appears. In the second cut west, what is probably red Claiborne sand uncomformably overlies gray, micaceous, kaolinic sand of the Cretaceous.

Dr. Vaughan has tabulated the fossils collected in the cut one mile east of Roberts. Collections have been made by G. D. Harris, S. W. McCallie, Earle Sloan, and T. W. Vaughan. The initials above the columns indicate the collectors.

Table of fossils from cut on Georgia railroad, one mile east of Roberts, Jones County.

NAME OF SPECIES	G. D. H.	S. W. M.	E. S. T. W. V.
Endopachys maclurii (Lea)			x
Cylichna sp.		x	
Plejona petrosa (Conrad)	x	x	x
Clavelithes sp.		x	
Mazzalina sp.			x
Fusus (Levifusus) trabeatus Conrad			x
Chrysodomus striatus ?	x		
Pseudoliva vetusta (Conrad)			x
Turritella apita de Greg		x	
Turritella nasuta Gabb			x
Turritella clevelandia Harris	x		
Turritella carinata Lea		x	
Turritella arenicola Conrad			x
Natica semilunata Lea		x	x
Calyptrea aperta (Sol.)		x	
Adeorbis sp.		x	
Nucula ovula Lea	x	x	x
Yoldia aldrichiana	x		
Yoldia aff. psammotaea Dall		x	
Leda aff. albirupiana Harris		x	x
Leda plicata Lea			x
Trigonarca sp.		x	
Trigonarca sp.			x
Glycymeris staminea (Conrad)			x
Glycymeris trigonella (Conrad)		x	x
Cucullaea macrodonta Whitfield			x
Ostrea alabamiensis Lea			x
Pteria limula (Conrad)			x
Pecten wilcoxii Dall			x
Amusium sp.		x	
Modiolus alabamensis Aldrich		x	
Periploma sp.	x		x
Venericardia planicosta Lamarck	x	x	x
Protocardia leñis	x		
Lucina papyracea Lea		x	
Lucina cf. pandata Conrad	x		
Lucina claibornensis Conrad		x	x
Cytherea var. nuttalliopsis Heilprin	x		
Cytherea texacola Harris			x
Cytherea subimpressa Conrad			x
Psammobia ozarkana Harris	x		
Psammobia blainvillei Lea ?		x	
Psammobia papyria Conrad ?		x	
Spisula parilis (Conrad)			x
Corbula oniscus Conrad		x	x
Corbula alabamiensis Lea		x	x

Dr. Vaughan states: "Of the specimens collected by Professor McCallie, Mr. Sloan and myself, only *Cucullæa macrodonta* and *Cytherea subimpressa* suggest Wilcox age; however, the horizon is low in the Claiborne, probably the very base, as indicated by *Turritella nasuta, Pecten wilcoxii, etc.,* and their overlapping with two species usually not ranging above the Wilcox."

Griswoldville.—The red sand which appears at Roberts (see section, page 280) can be traced, covering the ridge, three miles south to the cuts on the Central of Georgia Railway, one and a quarter miles west of Griswoldville. Here the red, argillaceous sands fill erosion gullies in Cretaceous beds. About three-quarters of a mile south of these cuts there is a notable exposure of quartzite full of casts and silicified shells. This rock has the appearance of having been originally a calcareous sand. It lies near the base of the Claiborne and is 100 feet or more below the tops of the high ridges which are made up of red, argillaceous sand. The quartzite is probably only a local deposit. The hard rock here is provisionally considered a part of the Congaree clay member.

Prof. G. D. Harris[1] has made the following notes:

"About a year ago, while on our way to take charge of geological work in Louisiana, we collected at some fine fossiliferous localities of this horizon in the vicinity of Griswold, and heard of several others in the same general region, but had no time to inspect them. This outcrop is in a V-shaped valley about two miles south of Griswold, or about 10 miles east of Macon. The lower Claiborne rock consists of a hard bed of the typical "buhrstone" of former geological works, about 10 feet in thickness, replete with fossil remains. In less indurated, or in sandy seams, and just below the main bed many fine specimens of silicified shells were collected. Sandy beds were noted below the above mentioned hard layer for a distance of 40 feet. Above and between this outcrop and the station, red sandy hills rise to the height of 140 feet above the fossiliferous bed or above the station, the latter two points being upon about the same level. Near the station were noted red sands mottled with white clay. One mile west of Griswold extensive white clay deposits were found along the line of the railway leading to Macon."

Prof. McCallie has collected fossils on the property of J. R. Van Buren and Company, one and one-half miles west of Griswoldville, which Dr. Vaughan has identified as follows:

Fossils from J. R. Van Buren Company's property.

"Platytrochus stokesi (Lea)
Flabellum cuneiforme Lonsdale
Turbinolia pharetra Lea
Endopachys maclurii (Lea)
Turbinella sp.
Pleiona sp.
Levifusus trabeatus Conrad
Mesalia vetusta (Conrad) ?
Calyptrea aperta (Solander)
Dentalium aff. blandum de Greg.
Nucula ovula Lea
Nucula magnifica Lea
Crassatellites protextus (Conrad)
Phacoides cariniferus (Conrad)
Protocardia sp.
Corbula alabamiensis Lea
Panopea sp.

[1]American Paleontology, Bull. No. 16, 1902.

"The species obtained at this locality are not sufficiently restricted in their stratigraphic range to decide where in the Claiborne group the exposure belongs."

BIBB COUNTY

Macon.—Both the Congaree clay member and Barnwell sand appear in gullies 10 miles southeast of Macon, near the eastern boundary of Bibb County. Prof. McCallie furnishes the following section:

Section in Macon-Marion public road, ten miles southeast of Macon.

	Feet.
McBean formation, (Congaree clay member).	
7. Red clays	5
6. Porous, cream-colored clay with fossil leaves and bivalves	10
5. Clay filled with bivalves	1.5
4. Same as No. 6, with no fossils, but containing sand partings	8
3. Same as No. 6	10
2. Fossiliferous sandstone and chert	10
1. Crossbedded sands and white clays	30

Fossils from this locality are *Nucula ovula, Diplodonta, Crassatellites protextus,* and several species of fossil leaves.

Exposures of fullers earth and sand appear in large gullies on the John Tharpe estate near the public road. The following section was made at or near the same locality as the preceding section:

Section in gullies on Tharpe estate.

	Feet.
Barnwell sand.	
11. Fine, red sand	50
McBean formation, (Congaree clay member).	
10. Thick-bedded, fullers earth, partly concealed by the "creep" of the overlying red sand	15
9. Alternating thin layers of clay and fine sand	10
8. Heavy-bedded fullers earth	5
7. Fullers earth, sand partings	15
6. Thick layered, jointed fullers earth	5
5. Interval concealed	} 20
4. Thin layers of clay, sand partings	
3. Thick layers, sandy	
2. Concealed interval of a few feet	?
Lower Cretaceous.	
1. White clay and sand	

The fullers earth contains casts of fossils, leaf impressions, and bits of lignitic wood.

ECONOMIC GEOLOGY OF McBEAN FORMATION

The Congaree member contains beds of fullers earth at several localities between Grovetown and Ocmulgee River, which should

prove to be of considerable economic value. A bed of fullers earth is at present being mined near Pike's Peak station, Twiggs County, by the General Reduction Company, and some development work was done several years ago on the Fiske property at Grovetown. The better quality of the fullers earth of this formation possesses excellent clarifying properties, fully equal to or superior to those of the English earth. In the tests which have been made it has not proved equal to the English earth for clarifying culinary oils, but it should prove suitable for other uses to which fullers earth is put. The McBean fullers earth occurs in enormous quantities, the beds in places reaching a thickness of as much as 50 feet.

McBean marls occur in abundance in the bluffs of Savannah and Chattahoochee rivers, and at localities in Burke, Jefferson and Washington counties. The marls, in addition to lime, contain small amounts of phosphoric acid and potash, and on certain soils and under certain conditions should be of local value as a land fertilizer.

Lime has in the past been manufactured from a shell bed near Griffin's Landing, Savannah River, Burke County; near Sunhill, Washington County, and near Bond's Store, Bibb County. However, under present industrial conditions, lime manufacture as a permanent industry would not be profitable in this region, on account of the high price of fuel, unfavorable quarrying condition, the general softness of the rock, and the presence of a high precentage of sand and clay impurities. However, it is suggested that where lime is desired for local agricultural purposes, the limestone and marl might be advantageously used at several localities. In this case expensive kilns and equipment would be unnecessary.

The Congaree clay members of the formation contains clay of some commercial value. Plastic clay from this member is being utilized, mixed with other clays, in the manufacture of sewerpipe and fire clay products, near Harlem, Columbia County, and at Stevens Pottery, Baldwin County.

A deposit of lignite and lignitic clay occurs three miles south of Grovetown (see page 270), and has been developed in a small way. The lignite is in thin beds, interbedded with dark colored or lignitic clay; the combined thickness exposed in a prospect pit is 12 feet. Although a large number of nearby exposures of strata have been examined, no evidence of any considerable amount of lignite has been found. It is believed that the area underlain by the lignite is very small, and that it is not in sufficient quantity to be an important source of fuel, although this particular deposit may possibly have a small local value. A small amount of the lignite and lignitic clay has been mined and sold as a filler for commercial fertilizers.

BARNWELL SAND

NAME

Mr. Earle Sloan[1] has used the name Barnwell "buhr sands" or Barnwell "phase" for red, ferruginous sands that immediately overlie the McBean formation, as defined in this report. The type area of the Barnwell sand is in Barnwell County, S. C., where its stratigraphic position is as stated. Sloan, who has also studied the area in Georgia adjacent to Savannah River, states that the Barnwell "phase" is represented by the sands that overlie the fossiliferous marls of Shell Bluff. As there are sands of lower stratigraphic position but very similar in appearance to the Barnwell, Sloan, in several instances, confused the lower horizon with his Barnwell. A notable instance of this confusion is seen in his referring to the Barnwell the fossiliferous sands near Hixon's bridge on Tinker's Creek.[2] The horizon of the fossils of this exposure is far down in the McBean formation. However, it is evident that Sloan intended this name to apply to the red, ferruginous sands of the upper horizon and not to those of the lower. He has orally given the information that he has found *Turritella carinata* Lea in the Barnwell sand in Barnwell County, S. C., and he is positive in his opinion that in the type area there is similarity in stratigraphic position, and in both lithologic and faunal characters with the fossiliferous, red, ferruginous sands overlying the McBean formation in Burke County, Ga.

DEFINITION

Stratigraphic relations.—The Barnwell sand directly overlies the McBean formation and is in contact with both the marls and the Congaree clay member of the latter formation. The nature of the contact separating the Barnwell sand from the McBean formation has not been satisfactorily determined. There is evidence, however, that along the northern margin of the Barnwell sand area the relation is that of unconformity,—the unconformity being of local and not of regional extent. Farther southward the Barnwell sand seems to overlie the McBean formation conformably. The probable explanation of this discordance of relationship in different parts of the area is that after the deposition of the clays and marls of the McBean formation there was an uplift of the region causing the shore line of the Claiborne sea to recede southward a short distance, permitting eros-

[1]Handbook of South Carolina, pp. 86, 90: Department of Agriculture, Commerce and Immigration, Columbia, S. C., 1907.
Catalogue of the Mineral Localities of South Carolina, pp. 449, 460: South Carolina Geol. Survey, 1908.
[2]Catalogue of the Mineral Localities of South Carolina, pp. 268, 460.

ion in the emerged area, followed, after a relatively short period, by resubmergence and a renewal of deposition over the entire Claiborne area.

The Barnwell sand is overlain by the Jackson formation but at no place has the exact contact between the two been observed; for this reason the nature of the contact is imperfectly known. There is some evidence in favor of a faunal and lithologic gradation, and on the other hand, a suggestion of unconformity (see page 296).

In Burke and Screven counties the formation is overlapped by the Vicksburg formation, and questionably by the upper Oligocene (Chattahoochee and Alum Bluff formations). In the eastern part of the State the Altamaha (Lafayette?) formation probably originally covered a large part of it, as there are now two prominent extensions of the Altamaha (Lafayette ?) at Tennille and Waynesboro. The Barnwell sand is in places covered with a small thickness of surficial gray sand of problematic origin, and by Pleistocene terrace deposits along the rivers.

Lithologic characters.—The Barnwell sand consists largely of unconsolidated red and vari-colored sands, but there are also thin layers of sandstone, quartzite, silicified limestone or flint, and thin layers of siliceous limonite, embedded in the sands. The sands, especially where weathered, have a somewhat similar appearance to the red, residual sands of the Vicksburg formation, which seem to be in contact with it in the southeastern part of Burke County, and, where fossils are absent, it is difficult to discriminate between the two.

The flint and quartzite contain casts and siliceous replacements of fossils and good collections have been obtained at several localities. The sand itself is poorly fossiliferous, containing only imperfect casts and moulds of fossils and fragments of silicified wood.

Thickness.—The maximum measured thickness of the Barnwell sand is 105 feet, this thickness being observed on Storm Branch below Cox Spring, about two miles northeast of Shell Bluff postoffice; therefore, the formation in places reaches a maximum thickness of over 100 feet.

Paleontologic characters.—Among the common fossils of the Barnwell sand are: *Mortonia, Mesalia vetusta* (Conrad), *Turritella carinata* Lea, *Glycymeris staminea* (Conrad), *Crassaltellites protextus* var. *lepidus* Dall, *Venericardia alticostata* (Conrad), *Cytherea perovata* Conrad, *Spisula praetenuis* (Conrad), etc. The best collection of fossils from a single locality is that from Old Town, seven and one-half miles southeast of the present site of Louisville. A list of the species is given on page 292.

Areal distribution.—The Barnwell sand of the Claiborne group is practically co-incident in its distribution with that of the Claiborne group as a whole. The formation overlies both the marls and the clays of the McBean formation and extends to the Fall Line. It is present over parts of the following counties: Columbia, Richmond, Burke, McDuffie, Jefferson, Glascock, Washington, Hancock, Wilkinson, Baldwin, Twiggs, Jones, and Bibb. No evidence was found indicating that the fossiliferous red sands in the southern part are later in age and superimposed upon the sands which near the Fall Line overlie the Congaree clay member and fullers earth. It is probable that red sands between Flint and Chattahoochee rivers belong to this formation but as yet no positive statement can be made. The sand forms the conspicuous red soils of the Claiborne group and lends character to this area of the Coastal Plain.

This formation is particularly well developed in Burke County,[1] where it contains fossiliferous flint and appears at the surface as a dark red, ferruginous sand. It is also well developed over other counties to the west.

Physiographic expression.—The Barnwell sand has been an important factor in determining the character of the topography in the region of its occurrence. The greater part of the area is hilly and broken, since the friable sands and soft clays of the formation have yielded readily to erosion. In Twiggs, Wilkinson, and Washington counties, valleys have been cut 150 to 200 feet below the level of the ridges and small plateaus, and the hills are often furrowed by deep gullies and ravines. In Burke and Jefferson counties there are flat plains in which limesinks occur, due to the collapse of solution cavities in the underlying McBean formation.

Structure.—The bedding planes of the Barnwell sand have been largely obscured as the result of the chemical changes which have taken place in the materials. For this reason it has been impossible to obtain accurate dip observations. However, there is doubtless a low dip of the beds to the southward or southeastward, probably not exceeding 10 or 15 feet to the mile.

LOCAL DETAILS

BURKE COUNTY

Storm Branch and Cox Spring.—Marl containing *Ostrea georgiana* and belonging to the McBean formation, was found on Storm Branch below Cox Spring, and one and three-quarters to two miles northeast of Shell Bluff post-office. Typical Barnwell sand overlies the marl at this locality.

[1]Note by Doctor Vaughan: These sands over most of Burke County are the equivalent or approximately the equivalent of the Gosport greensand of Alabama.

A section three-quarters of a mile below Cox Spring shows the following:

Section three-quarters of a mile below Cox Spring.

	Feet.
Barnwell sand.	
4. Red sand containing a few thin layers of flint	85
McBean formation.	
3. Argillaceous, sandy marl; contact with the above sand obscured. This layer contains *Caricella*, *Pseudoliva vetusta*, *Crassatellites protextus* (?), *Cytherea*. Thickness exposed	3
2. Soft, white, sandy marl containing *Ostrea georgiana* .	3
1. Concealed to the swamp level	2

At Cox Spring fossils were collected from thin flint layers in red sand, which are 8 to 10 feet higher than the marl bed No. 2 of the preceding section. The fossils identified are: *Platytrochus stokesi* (Lea), *Turritella carinata* Lea, *Mesalia* sp., *Astarte* sp.

The section at Mobley Bluff, one mile below the spring, is as follows:

Section at Mobley Bluff.

	Feet.
Barnwell sand.	
10. Red sand	15+
9. Red sand containing fragmental layers of flint and quartzite, a few indeterminable fossils	4 ?
8. Red sand	8
7. Sand with very thin layers of drab clay	5
McBean formation.	
6. Soft, argillaceous marl and clay; fossils *Crepidula*, probably *lirata*, *Calyptrea aperta*, *Nucula*, *Modiolus* *Crassatellites* probably *protextus*	3
5. Hard marl, a few large oyster shells	4
4. Soft, sandy marl and clay	3
3. Bed of large *Ostrea georgiana*	3
2. Soft, calcareous, sandy clay	11
1. Concealed to level of swamp	2

The localities are one and one-half miles southwest of the marl exposure in Cox ravine described by Dr. Vaughan, (see page 242).

The red sand with flint layers reaches a thickness of over 100 feet in this part of Burke County.

Waynesboro.—Fossiliferous flint of the Barnwell sand occurs in the railroad cut two miles north of Waynesboro.

Section in railroad cut two miles north of Waynesboro.

	Feet.
Barnwell sand.	
3. Red soil and limonite fragments	3
2. Fossiliferous, sandy flint in red residual clay	6
1. Argillaceous, coarse, quartz sand	7

Characteristic Claborne fossils have been identified from this locality.

At Rocky Creek church, five miles west of Waynesboro, there is an exposure of 15 feet of fossiliferous flint overlain by red argillaceous sand. Dr. Vaughan collected at this locality *Turritella carinata* (Lea), *Glycymeris staminea* (Conrad), *Crassatellites protexus* var. *lepidus* Dall, and *Cytherea perovata* Conrad. Residual fragments or boulders of flint are common south of this locality, and were noted to a point on the Midville road nine miles southwest of Waynesboro.

A siliceous or sandy chert layer, five feet thick, embedded in bright red, pebbly sand occurs on the Shell Bluff road on the west side of Briar Creek, three miles northeast of Waynesboro. Between the five and six mile-posts on the same road, residual flint fragments containing *Mortonia, Turritella,* etc., appear over the surface.

Dr. Vaughan has determined Claiborne fossils from residual flint in red sand at Thompson's bridge over Briar Creek, nine miles east, and at Dr. Steiner's farm five miles southwest of Waynesboro. These exposures and the red sand at McBean belong to the Barnwell sand.

Midville.—Flint rock is exposed at the Jones Mill site (also known as Burton Mill) five miles north of Midville. There is an exposure, six feet in thickness consisting of both porous and tripoli-like flint, jasper, and chalcedony. It contains poorly preserved fossils,—*Turritella carinata* and *Crassatellites protexus* have been identified. The surface north of Midville is a red, residual sand covered with a thin veneer of gray sand. The Midville flint is correlated with that in the vicinity of Waynesboro.

Boyd Farm.—At a point about four and one-half miles west of Hancock Landing, Savannah River, beds of flint were found in the red sand formation, and fossils were collected from it. This locality is at a spring on the Percy Boyd farm, about three and one-half miles southwest of Shell Bluff postoffice. The stratum lies at least 20 to 30 feet higher than the *Ostrea georgiana* bed, which was found on the edge of the swamp of Newberry Creek, about three-quarters of a mile southwest.

List of fossils near spring on Percy Boyd's farm, three and one-half miles southeast of Shell Bluff postoffice.

Turbinolia pharetra Lea
Mortonia
Turritella carinata Lea
Mesalia vetusta (Conrad)
Lunatia vicksburgensis (Conrad)
Leptothyra sp.
Dentalium thalloides Conrad
Glycymeris
Venericardia parva Lea
Phacoides alveatus (Conrad)

The sand and flint at this locality are characteristic of the Barnwell sand.

Stony Bluff, Savannah River.—No exposures of consequence appear between Limekiln Bluff and Stony Bluff, a distance of 14 miles by the river. At Ellison's Landing, there is a swamp bluff lying about 150 yards back from the river, but the exposures are poor and only red sand and white sandstone or quartzite is exposed. There is a lithologic change in the character of the strata, the marls apparently having dipped beneath the level of the river. The rock at Stony Bluff, which is about 25 feet high, consists of ledges and residual, scattered fragments of brittle, translucent, opaline flint and sandstone or quartzite embedded in coarse, red sand.

Section at Stony Bluff.

		Feet.
Age ?		
6.	Gray sand covering a gradual ascent to higher land	
5.	Red sand; scattered flint fragments; small amount of quartz gravel	30
Barnwell sand.		
4.	Quartzite layer	1.5
3.	Red sand, small quartz pebbles	1
2.	Sandstone, or quartzite	5
1.	Red or brownish argillaceous sand, sandstone fragments near the river level	15

Only a few poorly preserved fossils were noted in the flint. On the basis of lithologic similiarity the strata here are correlated with the flinty Barnwell sand in the vicinity of Waynesboro and elsewhere. Its geographic position also suggests the likelihood of its being the equivalent of the red sands in the upper parts of the bluffs from Shell Bluff southward.

RICHMOND COUNTY

Hephzibah.—Hephzibah is in a direct line, 12 miles southeast of Grovetown. The Congaree clay member of the McBean formation is here observed in contact with the white clays and coarse sands of the Lower Cretaceous. The fullers earth and clay at Grovetown are here represented by a small thickness of aluminous, shaly sandstone, containing leaf impressions and thin-layered, brittle, vitreous quartzite, which contains fossils. The overlying material is red sand and represents the Barnwell sand. An excellent exposure appears in the clay pits of the Albion Clay Company one mile west of Hephzibah.

Berzelia.—A section of a hill on Sandy Run Creek, four miles south of Berzelia, on the farm of H. Merry, near his residence, shows the following:

Section on farm of H. Merry.

	Feet.
Eocene.	
Barnwell sand.	
6. At the top, gray sand covering the surface; some small pebbles	3
4. Red, white, and purplish sands containing small pebbles in places	80
McBean formation, (Congaree clay member).	
3. Hard, bluish-gray claystone; massive, breaks with conchoidal fracture, and has the appearance of being silicified fullers earth	15
Lower Cretaceous.	
2. Hard, white clay	10
1. Talus of clay and sand	

Division No. 3 represents a new aspect of the fullers earth. A similar silicified clay occupying the same stratigraphic position was found a few miles to the south.

JEFFERSON COUNTY

Louisville.—The following section was made along the Clark's Mill road three and one-half miles northwest of Louisville:

Section along Clark's Mill Road.

Barnwell sand.	Feet.
5. At top of hill, red sand, no pebbles	25
4. Siliceous, "rotten" limestone, contains *Scutella*, *Turritella*, and other fossils	7
3. Red quartz sand	25
2. Limestone fragments in sand which appear to have been transported	1
1. Red sand	15

There is an exposure of fossiliferous sandstone and quartzite at Clark's Mill, seven miles northwest of Louisville.

Section at Clark's Mill.

Barnwell sand.	Feet.
3. Red sand, similar to that covering the upland underlain by the Claiborne group	
2. Gray sandstone and vitreous quartzite, containing fragments of shells, varies from 2 or 3 feet to	8
1. Red sand	5

Along the road from Louisville to Spread red sand at the surface is continuous, but in places is covered with a thin coat of gray sand of probable residual origin. Fragments of sandstone appear at a number of places. Northwest of Louisville evidence of lime sinks may be seen in the plain.

The following notes and list of fossils has been supplied by Dr. Vaughan:

Considerable collections of fossils have been made at Old Town, seven and a half miles southeast of the present site of Louisville, by Prof. S. W. McCallie, Earle Sloan, and myself.

List of fossils from Old Town, seven and one-half miles southeast of Louisville.

Mortonia sp.
Caricella pryuloides Conrad
Turritella carinata Lea
Mesalia vetusta (Conrad)
Calyptrea aperta (Sol.)
Glycymeris staminea (Conrad)
Glycymeris idonea (Conrad)
Glycymeris n. sp.
Crassatellites protextus var. lepidus Dall
Crassatellites n. sp.
Venericardia alticostata Conrad
Cytherea perovata Conrad
Spisula praetenuis (Conrad)
Corbula densata Conrad
Lunulites distans Lonsdale

"The fauna is upper Claiborne. *Lunulites distans* is an important fossil for correlation purposes, as its range is from the upper Claiborne (i. e. above the *Pteropsis lapidosa* zone) into the Jackson. Therefore, when found in association with such Claiborne species as *Turritella carinata*, *Venericardia alticostata*, etc., the horizon in the Claiborne group is definitely given.

Wadley.—Flint fragments containing fossils are exposed at the bridge of the Wadley Southern Railroad, three-quarters of a mile south of Wadley. These fragments are overlain by 15 feet of red sand, and a short distance southward the typical Altamaha (Lafayette ?) formation appears.

Dr. Vaughan furnishes the following note and list:

"Professor McCallie obtained from the Central of Georgia Railway well at Wadley, at a depth of 30 feet, the following fossils:

Fossils from well at Wadley.

Flabellum cuneiforme Lonsdale
Platytrochus stokesi (Lea)
Endopachys maclurii (Lea)
Mesalia vetusta (Conrad)
Calyptrea aperta (Sol.)
Nucula ovula Lea
Leda multilineata Conrad
Cytherea perovata Conrad
Venericardia alticostata (Conrad)
Corbula densata Conrad
Lunulites distans Lonsdale

"The geologic horizon is upper Claiborne."

In the southeastern part of the county, flint, both porous and compact or vitreous, containing fossils and evidently a replacement of limestone, appears at a number of places in beds and residual fragments. Fossils, characteristic of the Claiborne group, have been identified from the flint outcrops. The beds belong to the Barnwell sand.

WILKINSON COUNTY

The Claiborne group in Wilkinson County consists mainly of sands, clays, and local patches of limestone, resting unconformably upon the Lower Cretaceous. The strata reach a maximum thickness of 150 to 200 feet. The general succession of beds is as follows:

General section of the Claiborne group in Wilkinson County.

Eocene.	
Barnwell sand.	Feet.
3. Red and yellow, highly ferruginous sands, argillaceous and pebbly in places, which cap the ridges and hills (approximately)	10-100
McBean formation, (Congaree clay member).	
2. Massive and laminated, drab and greenish clays, and local beds limestone (approximately) . .	10-75
(Unconformity)	
Lower Cretaceous.	
1. Thick, white, clay beds and coarse kaolinic sand . . .	

McIntyre.—There are a number of exposures north of McIntyre where the Barnwell sand lies in contact with the kaolin beds of the Cretaceous, the laminated, impure, fullers-earth clays not being so extensively developed as in the vicinity of Gordon. The basal sands are usually coarse, crossbedded, and contain balls and angular chunks of the Cretaceous white clays.

Section of hill, one and one-half miles north of the 159*th milepost of the Central of Georgia Railway, and one quarter of a mile east of J. R. Honeycutt's house.*

Eocene.	Feet.
Barnwell sand.	
6. At the top of hill; gray structureless sand	6
5. Red and yellow, argillaceous sand	45
4. White, laminated clay with sand partings	6
3. Red and yellow, coarse, crossbeddel sand, contains large chunks of white clay, evidently torn from the underlying Lower Cretaceous beds	20
2. Concealed a few feet	?
Lower Cretaceous.	
1. Bauxite and white and stained clay	20+

TWIGGS COUNTY

The red and vari-colored sands which are conspicuous as cappings on the ridges in the northern part of Twiggs County, are believed to belong for the most part to the Barnwell sand.

Dry Branch clay mines.—Good exposures of the Claiborne group, showing its relations to the Cretaceous, occur at the clay mines southeast of Dry Branch.

Section in old pit at the mines of the American Clay Company.

Eocene.	
Barnwell sand.	Feet.
6. Red sand, may reach a thickness of 40 or 50 feet, thickness in pit	10
McBean formation (Congaree clay member).	
5. Greenish, laminated clay layer	2
4. Red quartz sand	8
3. Layer of pisolitic clay boulders and pebbles. Clay veined with halloysite and has the appearance of bauxite	2
2. Red and white coarse quartz sand containing disseminated clay with delicate casts of fossils	6
Lower Cretaceous.	
1. Massive bed of white and cream-colored clay	18

Section in one of the pits of the Atlanta Mining and Clay Company.

Eocene.	
Barnwell sand.	
9. Red sand, seen to the top of the ridge, 60 or 70 feet above	3
McBean formation (Congaree clay member).	
8. Greenish, tough, waxy clay	4
7. Fine-grained, red sand	5
6. Dark, greenish clay layer	1
5. Red micaceous sand	5
4. Yellow ochreous sand	3
3. Sand containing white clay pebbles	3
2. Fine, white kaolinic, crossbedded sand	8
(Unconformity)	
Lower Cretaceous.	
1. White, massive clay bed and arkosic sand	12+

Jeffersonville.—Bright red sand is conspicuous on the higher land in the vicinity of Jeffersonville and Fitzpatrick, but this sand becomes yellow and lighter colored in fresh exposures. The red sands become argillaceous in depth and are underlain in places by heavy beds of fullers earth-like clays.

The following section was made from exposures in a deep gully on the H. W. McCrary farm, two miles northeast of Jeffersonville:

Section in gully two miles northeast of Jeffersonville.

	Feet.	In.
Barnwell sand.		
13. Red sand, attains much greater thickness and is seen on the slopes to the top of the ridge	10	
12. Yellow quartz sand	10	
11. Red and yellow, tough and waxy, laminated clay with sand partings	4	
10. Alternating thin layers of white sand and yellow clay	3	
9. Yellow clay	0	2

		Feet.	In.
8.	White sand	0	4
7.	Yellow clay	0	3
6.	White sand	0	6
5.	Greenish clay	0	5
4.	Yellow argillaceous sand	2	
3.	Layer of sand and comminuted shells in places consolidated into sandstone	1	
2.	Yellow clay and sand	2	6
1.	Fine-grained, laminated clay with sand partings	4	

Prof. McCallie collected fossils from this locality which were identified by Dr. Vaughan as follows: *Turbinella* (*Psilocochlis*) *mccalliei*, Dall, *Buccinanops altile* (Conrad), *Mesalia vetusta* (Conrad), *Cytherea discoidalis* Conrad, *Venericardia planicosta* Lam. *Corbula alabamiensis* Lea.

The whole section at McCrary gully is provisionally referred to the Barnwell sand.

BIBB COUNTY

Browns Mountain.—Prof. McCallie collected from a sandy chert at this locality, a number of fossils which were identified by Dr. Vaughan as follows:

Fossils from Brown's Mountain.

Flabellum cuneiforme Lonsdale
Endopacys maclurii (Lea)
Mortonia sp.
Calyptraphorus velatus Conrad
Turritella carinata Lea
Mesalia vetusta (Conrad)
Calyptrea aperta (Solander)
Nucula ovula Lea
Pteria sp.
Pecten wahtubbeanus Dall
Crassatillites protextus var. lepidus Dall
Astarte smithvillensis Harris
Venericardia alticostata (Conrad)
Phacoides cariniferus (Conrad)
Phacoides alveatus (Conrad)
Ptrotocardia nicolleti Conrad
Cytherea perovata Conrad
Cytherea, 2 sp.
Psammobia sp.
Panopaea porrectoides Ald.
Corbula oniscus Conrad

The summit of the hill is about 180 feet above the adjacent Pleistocene terrace of Ocmulgee River. The lower 110 feet consists of gray and white crossbedded sand, and thin white clay layers of Lower Cretaceous age. The upper 70 feet of the exposure has fossiliferous chert and sandstone at the base, while the upper slopes are red, argillaceous sand.

Prof. McCallie gives the following notes:

Section of Brown's Mountain, nine miles southeast of Macon.

Barnwell sand.

4.	Reddish, sandy clays	10 ?
3.	Yellowish, white clay, fossiliferous	20 ?
2.	Sandy fossiliferous chert	25 ?
1.	Clay resembling No. 3, but no fossils	

"The thickness of the different strata here given is only approximate there being no point at which both the upper and lower layers are exposed."

It is believed that the strata of the Claiborne group at this locality belong to the Barnwell sand.

JACKSON FORMATION

NAME

The type locality of the Jackson formation is Jackson, Miss. From the study of a large number of fossils collected at this locality Conrad[1] concluded that the strata were paleontologically peculiar and gave the name Jackson to the formation. In Alabama[2] the formation is included in the St. Stephens limestone or "White Limestone" series, which comprises the Jackson and Vicksburg formations, as they could not be lithologically differentiated and had not been paleontologically studied.

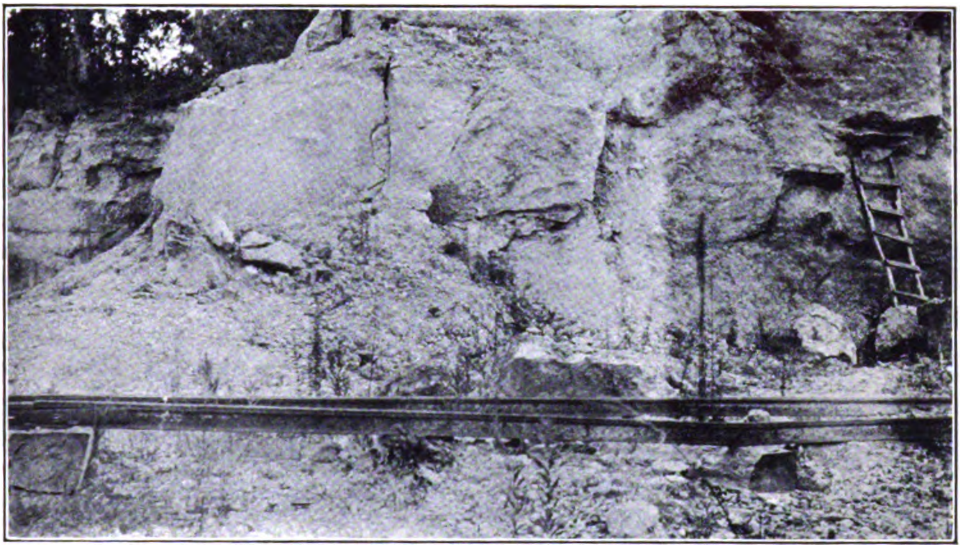
Brief mention of this formation in Georgia has been made by S. W. McCallie[3] and Otto Veatch[4] including it as a part of the "Vicksburg-Jackson," without differentiating it from the Vicksburg.

DEFINITION

Stratigraphic relations.—The formation represents the uppermost Eocene exposed in Georgia, and its stratigraphic position is between the Vicksburg formation above and the Claiborne group below. The line of division between the Jackson and the Claiborne has not been accurately located, and it can not be stated with certainty whether or not their deposition was continuous or interrupted. The two formations are similar lithologically. According to the evidence of the fossils, beds referable to the Jackson formation occur near the mines of the Georgia Kaolin Company in Twiggs County. Its existence at this locality can be explained only on the theory of deformation by faulting or folding or by an overlap and an erosion unconformity. Paleontologic evidence has also furnished grounds for the belief that an unconformity may exist between the two formations south of Perry in Houston County, (see pages 258-260). No unconformity, however, has thus far been observed in the field.

In Mississippi the Claiborne and Jackson groups seem to be closely related. Mr. A. F. Crider[5] states that "even where the formations have been best studied there seems to be a gradation in both the fossils and the stratigraphy from the upper Claiborne to the

[1] Proc. Acad. Nat. Sci., Philadelphia, Vol. 7, 1855, pp. 257-263.
[2] Smith, Johnson, and Langdon, Report on the Geology of the Coastal Plain: Geol. Survey of Alabama, 1894, pp. 107, 108.
[3] Underground waters of Georgia: Bull. Geol. Survey of Georgia No. 15, 1908, p. 33.
[4] Clay deposits of Georgia: Bull. Geol. Survey of Georgia No. 18, 1909, p. 75.
[5] Crider, A. F., Geology and Mineral Resources of Mississippi: Bull. U. S. Geol. Survey No. 283, pp. 33, 34.



A. EXPOSURE OF LIMESTONE OF THE JACKSON FORMATION IN A QUARRY NEAR THE GEORGIA, SOUTHERN & FLORIDA RAILWAY, ONE AND ONE-HALF MILES SOUTH OF TIVOLA, HOUSTON COUNTY.

B. EXPOSURE OF LIMESTONE OF THE JACKSON FORMATION IN A GULLY AT RICH HILL, FIVE MILES SOUTHEAST OF ROBERTA, CRAWFORD COUNTY.

lower Jackson." In Alabama, the Jackson has not been described as a separate formation, and very little specific information as to its relations with the Claiborne has been published. From the description given in the "Report on the geology of the Coastal Plain of Alabama[1] published in 1894 by the Alabama Geological Survey, it is evident that the two are closely related lithologically and faunally, and in sections where both are exposed no mention is made of unconformable relations.

Where the Jackson and the Vicksburg formations have been observed in the same section in Georgia there is no evidence of an unconformity or break in the deposition of the strata.

The Jackson at Rich Hill, five miles southeast of Roberta, Crawford County, rests directly upon Lower Cretaceous strata, and marine deposits at this locality indicate that the Jackson formation originally extended much farther northward than at present and suggests that the formation may have even lapped over the crystalline rocks of the Piedmont Plain.

Lithologic characters and thickness.—The formation consists of white or cream-colored, massive-bedded limestones, thin beds of marl and calcareous, glauconitic, and sandy, laminated clays. The limestones are highly fossiliferous in places consisting almost entirely of a friable mass of Bryozoa and shells. Southward from Perry there is a considerable thickness of loose red and yellow quartz sand and clay, the stratigraphic position of which has not yet been fixed, but which may belong in part to the Jackson formation. Silicification of the limestone was noted one-half mile north of Bonaire, and also south of Perry, Houston County.

The thickness of the Jackson formation can not be determined with accuracy, mainly on account of uncertainty as to the location of the line of division between it and the Claiborne group. The formation has a low dip southward; the width of the outcrop is only a few miles, so that the total thickness probably does not exceed 150 feet. There is an exposed thickness of about 75 feet at Rich Hill, and about the same thickness south of Perry, not including the sands underlying the fossiliferous strata.

Paleontologic characters.—The limestones of the formation are highly fossiliferous, but the clays and sands only sparingly so. As in Mississippi and Louisiana, the formation in Georgia seems to mark the upper limit of *Venericardia planicosta*. In places, Bryozoa make up the greater part of the rock, this being especially true of the

[1]Pages 111, 128, 381, 383.

occurrences at Rich Hill, Crawford County, at Ross Hill, three and a quarter miles south of Perry, and at other localities. Of the 24 species which have been determined from the Jackson formation in Georgia, but six are common to the overlying Vicksburg formation. The whale-like mammal, *Zeuglodon* (*Basilosaurus*), is a characteristic fossil of the Jackson, and some fragments of its remains have been found in Georgia. As in the Vicksburg formation, *Pecten* and *Orbitoides*, are abundant; the species *Pecten perplanus, Pecten nuperus,* and *Orbitoides mantelli,* appear in both formations. All of the fossils which have been identified from the Jackson formation are given on succeeding pages.

Areal distribution.—The area underlain by the formation, so far as known, is small. The largest area is in Houston, Twiggs, and Pulaski counties. There is an isolated area at Rich Hill, Crawford County, and on Chattahoochee River near Alaga, Ala., there is a probable small occurrence which is mentioned by Langdon.[1] On Oconee River the strata exposed at Wring Jaw Landing, Johnson County, are referred to the Jackson by Dr. Vaughan. Further detailed work may reveal occurrences east of the Oconee. Evidence of the Jackson between Flint and Chattahoochee rivers has been found at only one locality, namely, on Ichawaynochaway Creek, one and one-half miles below Cordray Mill, Calhoun County. If it is present to any considerable extent as a surface formation it has not been distinguished from the strata of the Vicksburg formation and the Claiborne group.

Physiographic expression.—The limestone member of the formation has produced a prominent scarp on the south side of Indian and Mill Creeks in Houston County. Rich Hill, in Crawforw County, is a conspicuous topographic feature due to the greater resistance to erosion of the limestone and clays of the formation than that exerted by the Cretaceous sands and clays. A few limesinks occur north of Bonaire.

Structure.—The formation has a low dip southward. Visual evidence of folding was not noted in field work. However, in order to explain the conditions (see page 260) four and one-half miles south of Perry, either a fold or fault in the strata or an erosion unconformity between the Jackson formation and the Claiborne group is necessary.

Economic geology.—The limestones of the Jackson formation, south of Perry and south of Tivola, Houston County, could be used

[1]Report on the Coastal Plain of Alabama: Geol. Survey of Alabama. 1894, p. 383.

in the manufacture of lime or for road metal. The chief objection to the stone as a road metal is its softness; however, if used in conjunction with the flint rock, which also occurs in this part of the State, it should make a fair road-surfacing material. The bryozoan, friable limestones or marls, together with some glauconitic layers, mentioned in succeeding pages, should be of some local value as fertilizers, but up to the present they have not been so utilized.

LOCAL DETAILS

CALHOUN COUNTY

Cordray Mill.—The Jackson formation doubtless underlies the Vicksburg formation between Flint and Chattahoochee rivers, but an exposure has been found at only one locality. Probable Jackson occurs in the left bank of Ichawaynochway Creek, at Bateman "Hammock," one and one-half miles below Cordray Mill, 12 miles east of Edison.

Section at Bateman "Hammock"

	Feet.
Jackson formation.	
3. Red sand	10
2. Hard, white sandy limestone; contains a *Pecten*, probably *P. perplanus* Bryozoa, and a large oyster	3
McBean formation.	
1. Aluminous sand and sandstone, slightly calcareous; *Ostrea divaricata*	1

CRAWFORD COUNTY

Rich Hill.—One of the most interesting localities of the Jackson formation is at Rich Hill, five miles southeast of Roberta. The hill rises about 150 feet above the small valley on the south side, and is a conspicuous topographic feature. This is an isolated exposure and indicates that the northward extension of the formation was formerly much greater than at present. The hill is capped by brilliant red sand, probably referable to the Jackson formation, overlying the calcareous beds undoubtedly belonging to the Jackson formation; the latter rests upon white clays and sands of the Lower Cretaceous. The hill is deeply trenched by erosion gullies in which the strata are laid bare. The following section was made from the exposures in the gullies on the south side:

Section at Rich Hill.

	Feet.	In.
Eocene		
Jackson formation ?		
13. Brilliant red sand capping the hill and forming "creep" on the upper slopes	30	

		Feet.	In.
Jackson formation.			
12.	Purplish and yellow sand, containing thin clay laminae	12	
11.	Greenish, laminated clay, thin lignitic partings	4	
10.	Plastic, calcareous clay with fossils	0	6
9.	Drab, jointed laminated clay, with sand partings	6	
8.	Fossiliferous nodular calcareous layer	0	12
7.	Drab, soft, laminated clay with fossils; contains nodular, calcareous layers	12	
6.	Limestone, generally soft and friable but in places hard and compact; in places it is a bryozoan marl so soft that it may be scraped up with the hands. Fossils chiefly Bryozoa, *Pecten perplanus*, and *Mortonia sp.*; fish teeth are also abundant in places	20	
5.	Brown and yellow unconsolidated sand which in places is replaced by limestone	12	
Lower Cretaceous.			
4.	White, micaceous clay; maximum	10	
3.	White, crossbedded clayey sand	10	
2.	White micaceous clay	3	
1.	Coarse, white sand	10	

List of fossils from Rich Hill.

(Identified by T. W. Vaughan.)

Mortonia sp.
Plejona sp.
Calyptrea aperta (Solander)
Ostrea georgiana Conrad
Pecten perplanus Morton
Pecten (probably P. nuperus Conrad) young and poor specimen.
Venericardia sp.
Lucina sp., found also five and one-half miles south of Perry.
Panopaea sp.
(The Mortonia referred to above is also found at Castle Hayne and Wilmington, N. C., and nine miles east of Waynesboro, Burke Co., Ga.)

HOUSTON COUNTY

Bonaire.—A small exposure of limestone appears in the railroad cut one-quarter of a mile north of the station. The rock is very similar to that at the quarry south of Tivola described on a subsequent page. From this locality the following fossils[1] have been identified:

List of fossils from one mile north of Bonaire.

Mortonia sp.
Caricella sp.
Turritella sp.
Pecten perplanus Morton
Cytherea
Basilosaurus sp., probably B. macrospondylus (Harlan)

Residual boulders of both limestone and flint cap a hill one and one-half miles north of Bonaire, near the railroad. This is probably the northern limit of the Jackson formation, for to the northward

[1]Bull. Geol. Survey of Georgia No. 15, p. 351.

of this place there is a decided change in the character of the materials, and at Wellston there is an exposure having the characteristic appearance of the Cretaceous.

Perry.—Very good sections of the Jackson formation occur in the escarpment on the south side of Flat Creek and Mill Creek, at Ross Hill three miles south of Perry, and on the Perry Henderson road, five miles southwest of Perry. The section of the northern slope of Ross Hill, along the public road, is as follows:

Section at Ross Hill

	Feet.
Oligocene.	
Vicksburg formation.	
11. Flint fragments in red, clayey soil	10
Eocene.	
Jackson formation.	
10. Soft, fossiliferous limestone or marl	4
9. Largely concealed, but probably an argillaceous marl or calcareous clay	12
8. Limestone and marl	4
7. Laminated, fine-grained, drab clay; contains small friable, calcite nodules	15
6. Ash-colored, friable marl, made up of fragments of Bryozoa, pectens, echinoderms, etc.	5
5. Soft, fossiliferous limestone, more compact than the above layer	4
4. Yellow and ash-colored, fossiliferous marl	6
3. Hard, compact limestone	6
2. Massive soft, fossiliferous limestone; contains characteristic Jackson fossils	15
1. Greenish, fine-grained, laminated clay	10

A collection of fossils was made at this locality by Prof. McCallie and identified by Dr. Vaughan as follows:

List of Fossils from the Jackson Formation south of Perry

Locality.—Perry-Elko public road, three and one-quarter miles southeast of Perry.

Plejona petrosa (Conrad)
Fusoficula cf. filia (Meyer)
Turritella sp.
Calyptrea aperta (Solander)
Dentalium thalloides Conrad
Nucula ovula Lea
Leda multilineata Conrad
Leda sp.
Glycymeris sp.
Pecten perplanus Morton
Pecten cf. nuperus Conrad
Venericardia cf. rotunda Lea
Cytherea, 2 sp.
Spisula cf. funerata Conrad

At the same locality Veatch collected the following fossils from the limestone in the lower part of the hill:

Orbitoides
Mortonia sp.
Protocardia nicoletti Conrad

Along the road between this hill and Perry only vari-colored, unconsolidated sands appear. These sands evidently underlie the calcareous strata of the Jackson formation but their age has not been definitely ascertained. They probably belong either to the Jackson formation or to the Claiborne group.

Section five miles southwest of Perry along Perry-Henderson public road.

	Feet	In.
Oligocene.		
Vicksburg formation.		
13. Top of hill, red, argillaceous sand; characteristic appearance of the residual sand of the Vicksburg		
12. Residual flint and "rotten" limestone; contains fossils	6	
Eocene.		
Jackson formation.		
11. Red, sandy clay, containing quartzite nodules	15	
10. Gray, laminated, shaly clay, in the nature of fullers earth	6	
9. Glauconite layer	2	
8. Black clay	0	3
7. Glauconite layer	0	12
6. Gray and drab, calcareous clay; contains soft nodules of white calcite	10	
5. Limestone layer, very hard	0	6
4. White, soft, argillaceous limestone and ash-colored friable marl	3	
3. Strata concealed, probably limestone or calcareous clay	10	
2. Red and greenish, stiff, plastic, sandy clay; contains fossiliferous flint fragments	10	
Age?		
1. Red, unconsolidated sand to level of Mill Creek; contains fragments of silicified wood, but no other fossils	25	

Characteristic Jackson fossils have been identified from this locality. In proceeding north from Mill Creek to Myrtle, only vari-colored sands are exposed. Stratigraphically these sands lie beneath the Jackson formation. They may belong in part to the Jackson formation, but are more probably referable to the Claiborne group and Midway formation. From the preceding section Dr. Vaughan has identified the following fossils:

Fossils[1] *from Perry-Henderson road, five and a quarter miles south of Perry*

Flabellum cuneiforme Lonsdale
Endopachys sp.
Turritella
Leda multilineata Conrad

[1]Collection made by S. W. McCallie, Bull. 15, Geol. Surv. Ga., p. 351.

Leda, very large species, cf. pharcida Dall, but apparently new.
Lucina sp., also found in the clay bed at Rich Hill
Protocardia nicoletti Conrad
Corbula, apparently wailesiana Harris

Tivola.—A good section of the formation is exposed at the old quarry on the east side of the Georgia Southern & Florida Railroad, one and one-half miles south of Tivola.

Section at Georgia Southern & Florida quarry

	Feet.	In.
Oligocene.		
Vicksburg formation.		
16. Flint layers and fragments in red, argillaceous sand; strata partly concealed and actual contact with lower beds not seen; flint fossiliferous		
Eocene.		
Jackson formation.		
15. Greenish, laminated clay; contains calcareous concretions and thin sandstone layers	5	
14. Argillaceous limestone	0	5
13. Drab clay	2	6
12. Indurated, calcareous clay	0	6
11. Plastic, drab, laminated clay	4	
10. Hard, calcareous layer	0	3
9. Greenish or drab, laminated clay	4	
8. Sandstone	0	3
7. Yellow, laminated, calcareous clay	4	
6. Hard limestone	0	6
5. Soft limestone, contains fossils	0	12
4. Hard limestone, no fossils	0	12
3. Laminated clay	4	
2. Massive bedded, white and cream colored, highly fossilliferous limestone; contains Bryozoa pectens, *Orbitoides*, echinoids, a rather large oyster, and sharks' teeth; fragments of large bones are reported to have been found	25	
1. Stratum partly concealed, but probably a calcareous clay	?	

Stratum No. 16 has every appearance of the residual Vicksburg formation from which fossils have been identified a short distance south of this locality. The limestone is, on the whole, soft, but there is some hard rock which seems to be due to crystallization of the calcium carbonate. It is very fossiliferous, being made up entirely of organic remains; parts of the beds resemble the friable marl at Rich Hill; the section is, on the whole, similar to that at Ross Hill, three and one-half miles south of Perry. The rock here has been quarried for road metal. Northward from the quarry only sand is exposed. This is a red, fine-grained quartz sand with occasional thin, impure, clay layers; no fossils could be found but this sand does not appear to be of Pleistocene age or a surficial formation, and probably belongs to the Jackson formation.

The limestone again appears in a railroad cut two miles south of Tivola. A calcareous clay, probably a part of this formation, was noted a short distance east of Kathleen.

TWIGGS COUNTY

Near Dry Branch.—According to Dr. Vaughan the evidence of the fossils shows that Jackson strata occur near the mines of the Georgia Kaolin Company, two miles southeast of Dry Branch. There is an exposure of 15 feet of soft, white, argillaceous marl in a small ravine one-half mile southeast of the clay-working plant, which contains Bryozoa and other fossils, and is similar lithologically to the marl at Rich Hill. It lies 10 to 15 feet above the white clay beds of the Cretaceous, and is overlain by 125 feet of bluish or drab, laminated, sandy clay and red sand, the clay containing thin slabs of quartzite or sandstone. In this vicinity Claiborne fossiliferous strata occur at both higher and lower levels than this marl, and the presence of Jackson beds in this position implies either a deep erosion unconformity between the two formations, or a flexure. Exposures in this vicinity, so far as they have been examined, afforded no evidence either of an unconformity, or of any faulting or folding of the beds. Further detailed field work is necessary to solve this problem of stratigraphy.

List of fossils from ravine one-half mile southeast of the mines of the Georgia Kaolin Company, identified by T. Wayland Vaughan.

Platytrochus stokesi (Lea)	Protocardia
Mortonia	Tellina
Leda multilineata Conrad	Corbula densata Conrad
Pecten perplanus Morton	Bryozoa (very numerous)

Westlake.—On the old McRae plantation at a point about three and one-half miles northeast of Westlake, is an exposure of limestone that has the lithologic appearance of the Jackson formation. The soil at this particular locality is a tough clay with a much ranker vegetation than the higher sandy land. The rock is exposed at a few places, is highly fossiliferous, and has much the appearance of the limestone south of Tivola and Perry. However, *Amusium ocalanum* has been found here and this fossil suggests a higher horizon.

About four and one-half miles northeast of Westlake, on the Jeffersonville road, about 20 or 25 feet of calcareous, laminated clay similar to that above the limestone at Rich Hill and Tivola is exposed in a gully on the land of Mr. S. G. Kitchens. Scutella (?) was noted in calcareous layers in the clay. The higher land above this clay is

covered by a bright red, ferruginous, argillaceous sand in which there are scattered fossiliferous flint fragments having the aspect of the Vicksburg formation.

On the Macon-Cochran public road, on Shell Creek, near Westlake, Prof. McCallie collected *Pecten perplanus* Morton; on the same road one mile east of Westlake, he obtained *Platytrochus stokesi* (Lea), and *Endopachys maclurii.* (Lea). These exposures probably represent the Jackson formation. On the McRae farm, three miles east of Westlake, he collected *Mortonia, Pecten perplanus* Morton, and *Amusium ocalanum* Dall, which suggest the presence of the Vicksburg formation, since *Amusium ocalanum* has hitherto not been found lower than the Vicksburg.

PULASKI COUNTY.

Hawkinsville.—The Jackson formation appears on Ocmulgee River in the lower part of Taylor's Bluff, three miles above Hawkinsville.

Section of Taylor's Bluff three miles above Hawkinsville.

		Feet.
6.	Concealed by vegetation	32
5.	Massive wall of soft, argillaceous limestone, no bedding; few fossils	25
4.	Fossiliferous limestone, with alternate hard and soft layers; somewhat argillaceous	17
3.	Very hard, compact, greenish-gray clay	2
2.	Greenish-gray, calcareous sandstone	1
1.	Bluish drab, compact, sandy clay to water's edge	3

The fossils collected from the lower 20 feet of the section, *Flabellum cuneiforme, Sphenotrochus sp., Endopachys maclurii* (Lea), *Leda multilineata,* Conrad, *Venericardia planicosta,* Lam, and *Lunulites sp.,* are regarded by Dr. Vaughan as of Jackson age. *Amusium ocalanum,* collected 22 feet from the base of the bluff, indicates that the upper part is of Vicksburg age. No unconformity was observed between the two formations.

JOHNSON COUNTY.

Kittrells.—Prof. McCallie has furnished the following section descriptive of the strata exposed in the bluff at Wring Jaw Landing on Oconee River, two miles west of Kittrells.

Section at Wring Jaw Landing

Jackson formation.		Feet
8.	Massive, red, sandy clay	8
7.	Stratified, red, sandy clay	8
6.	Bluish, lignitic clay	8
5.	White and yellow sands	4

		Feet
4.	Bluish clay with fossil leaves	4
3.	Hard, glauconitic limestone, fossiliferous	8
2.	Bluish clay with fossil shells	2
1.	Soft glauconitic limestone or marl	

Dr. Vaughan has identified the following fossils from this locality:

List of fossils from Wring Jaw Landing

Orbitoides sp.
Flabellum cuneiforme Lonsdale
Platytrochus stokesi (Lea)
Endopachys maclurii (Lea)
Mortonia sp.
Nucula ovula Lea
Leda
Pecten perplanus Morton
Ostrea trigonalis Conrad
Protocardia nicolleti Conrad
Lunulites distans Lonsdale

Lithologically, the strata are similar to the Claiborne material near Sandersville and west of Tennille. The red sand which overlies the marl extends about seven miles east of the river, beyond which it becomes obscured by strata of Oligocene age and by the Altamaha (Lafayette ?) formation.

SAVANNAH RIVER

Johnson's Landing.—Dr. Vaughan examined an exposure of fossiliferous, silicified limestone on the South Carolina side of the river, on the north side of the upper road to the landing, in a field just above the margin of the river swamp. *Pecten perplanus* Morton and numerous Bryozoa were observed. This exposure probably belongs to the Jackson formation but the evidence is not entirely conclusive.

OLIGOCENE

VICKSBURG FORMATION

NAME

This division of the Tertiary receives its name from Vicksburg, Miss., where it was first studied and named by Conrad.[1] It is in part the equivalent of the St. Stephens limestone of Alabama, and includes in Florida[2] the Ocala, "Peninsular," and Marianna limestone. Vaughan[3] has recently stated that it is probable that the Florida divisions should be grouped as one formation. The St. Stephens limestone of Alabama has been traced from Mississippi to Chattahoochee River; it, however, includes the Jackson, whereas in Georgia the Jackson has been differentiated from the Vicksburg. The possibility of subdividing the Vicksburg in Georgia into two formations has been considered but the present work has not been sufficiently de-

[1] Prof. Acad. Nat. Sci., Philadelphia, Vol. 3, 1846, pp. 280, 281.
[2] Matson, G. C., and Clapp, F. G., Preliminary report on the geology of Florida; Florida Geol. Survey, 1909.
[3] Contributions to the Geologic history of the Floridian Plateau, Publication No. 133, Carnegie Institution of Washington, 1910, p. 150.

tailed to furnish either a lithologic or paleontologic basis for the consistent extension of such subdivisions across the area. That subdivisions may later be made is probable.

In the previous literature on Georgia geology this formation has been briefly described under the name "White Limestone series" by Spencer,[1] and under the names "Vicksburg-Jackson" and "Vicksburg" by McCallie,[2] Veatch[3] and others. Parts of the underlying Jackson formation and of the overlying Chattahoochee formation have been included under these divisions by the authors mentioned.

The Vicksburg formation or group was in the earlier literature referred to the Eocene division of the Tertiary, but in most of the more recent publications on Atlantic and Gulf Coastal Plain geology it has been placed under the Oligocene. The adoption of this European division (Oligocene) of the Tertiary in the classification of the strata of the Atlantic and Gulf Coastal Plain of the United States is due largely to the studies of Dr. W. H. Dall[4] of the U. S. National Museum.

DEFINITION

Stratigraphic relations.—The Vicksburg formation, which is classified as Oligocene, occupies a stratigraphic position between the Jackson and the Chattahoochee formations.

Contacts with the Jackson formation were seen in Houston and Pulaski counties where there seems to be no physical break between the two divisions.

West of Flint River, the Vicksburg extends northward to the Midway and Wilcox belts of outcrop, and has overlapped and largely obscured the Claiborne group and Jackson formation. Unconformable contacts with the Claiborne group, the Jackson apparently missing, were noted near Fort Gaines, Cuthbert, Shellman, Americus, and Andersonville.

Unconformable relations or erosion contacts have been observed between the Vicksburg formation and the overlying Chattahoochee formation, in the vicinity of Bainbridge, Decatur County, by Pumpelly and Vaughan (see under Chattahoochee formation). Northward from Decatur County, in the escarpment on the east side of Flint River, the Chattahoochee formation is doubtfully present in natural exposures, and the Vicksburg seems to be directly overlain by

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[1]Spencer, J. W., First Report of Progress; Geol. Survey of Georgia, 1890-1891.

[2]McCallie, S. W., Underground waters of Georgia; Geol. Survey of Georgia, Bull. No. 15, p. 33.

[3]Veatch, Otto, Clay deposits of Georgia; Geol. Survey of Georgia, Bull. No. 18, pp. 75-76.

[4]For a discussion of the Oligocene see papers by Dall: Proc. U. S. Nat. Mus., Vol. 19, No. 1110, 1896, pp. 303-305.

Table of North American Tertiary horizons, U. S. Geol. Survey, Eighteenth Ann. Rept., 1896-1897, part 2.

Trans. Wag. Inst. Sci., Philadelphia, Vol. 3, pt. 4, 1903, pp. 1546-1549.

the Alum Bluff, but it is probable that the Chattahoochee formation exists in this region and is merely concealed by weathering and by the Alum Bluff formation. Eastward in Dooly, Pulaski, Laurens, Burke, and Screven counties, and other counties along the northern margin of the formation, as the Vicksburg formation is overlapped and partially obscured by the Altamaha (Lafayette ?) formation, Alum Bluff formation, and by Pleistocene deposits, its relation to the Chattahoochee formation is not known, other than that it is stratigraphically lower than that formation.

Lithologic characters.—The formation is made up largely of white limestones, but also contains beds of sand and clay. The limestones have been extensively silicified and in many places do not appear at all at the surface, but are concealed by vari-colored, very coarse grained, sandy clays, which are probably residual, in which residual flint fragments are imbedded.

The limestones are generally white or cream colored, soft and earthy and very abundantly fossiliferous. Flat, disc-like *Orbitoides*, Bryozoa, and pectens, and their fragments form nearly the whole of the rock in places. Along Flint River the rock has a characteristic vesicular or pitted appearance due to solution. There are cave-like recesses in the bluffs producing a rough jagged appearance. Bedding planes and joint planes are almost entirely absent. At a few localities, however, the limestones are hard, white, and crystalline, and sufficiently pure for use in the manufacture of lime. The softer rocks contain varying percentages of silica and clay. The silica is generally not in the form of quartz grains, but has been introduced in solution in circulating waters replacing the limestone.

The limestones have been extensively silicified and the formation is often represented by flint fragments and large siliceous boulders; at no place does the flint appear in continuous, solid or undisturbed beds. The flint is either porous and tripoli-like, or brittle, compact and translucent, having been converted into jasper and chalcedony. The white porous flint is prominent wherever the Vicksburg is the underlying geological formation. The white or cream color is due to the porous condition of the rock, the silica of which when examined under the microscope is seen to be in translucent grains probably in the form of chalcedony. These flint rocks are in many places as fossiliferous as the limestones, and are evidently replacements of the soft, porous limestones of the Vicksburg formation.

The alteration in most cases has been complete, the rock rarely showing effervescence with acids. Some of the flint is dense, compact, vitreous or brittle and either translucent or red, yellow or brown.

This variety shows fewer traces of fossils than the porous flint, but it is probably a replacement of the limestones; as an exception, jasper in the form of nodules in the limestones, apparently produced by the segregation of silica and not by replacement has been observed at Albany.

Large boulders of flint appear along Flint River from Albany to Bainbridge and form some of the most picturesque spots along the river. The boulders are characteristically vesicular and contain spherical cavities an inch or more in diameter. These cavities appear to have been originally occupied by echinoids and often a spongy skeleton-like kernel of silica remains in place of the fossil.

The Vicksburg formation is deeply weathered, the weathered product appearing at the surface as deep red, argillaceous sands, containing scattered flint fragments and black and brown iron oxide accretions about the size of buckshot. Where the sands have been exposed to the atmosphere for long periods of time as in old railway and road cuts, they have become case-hardened or slightly cemented by iron oxide, and crack into polygonal figures. At a number of places the residual clays and sands present a mottled appearance not unlike that of the Altamaha (Lafayette ?) formation. The freshly exposed residue of decomposition and solution is a highly siliceous, bluish or gray, tenaceous clay.

Sand beds which probably belong to the Vicksburg formation have been reported in a number of wells. In a cut of the Central of Georgia Railway, one-half mile east of Dawson, there are two beds of varicolored sand associated with residual flint and clay, but which themselves do not appear to be residual.

Thickness.—The thickness of the formation can not be determined from natural exposures. Estimating from well records, the thickness in the western part of the State can hardly be more than 300 feet and at many localities is much less than this amount. Along the northern margin of the formation in Clay, Randolph, Webster, and Sumter counties, the thickness is less than 100 feet. Sepncer[1] estimated the thickness at Bainbridge to be 500 feet. It is probable, however, that a part of the strata included by him in the Vicksburg formation should have been referred to the underlying Eocene. The formation also appears in Burke and Screven counties, but no data for estimating its thickness in that region are available; however, it probably does not exceed that in the western part of the State.

Paleontologic characters.—The formation is highly fossiliferous. The most abundant forms are foraminifera and bryozoans. So abundant is one genus, *Orbitoides,* a flat, disc-like foraminifera, va-

[1]Report of Progress, Geological Survey of Georgia, 1890-1891, p. 55.

rying from one-quarter inch to two inches in diameter, that the formation has been named in older literature the "Orbitoidal limestone." The fauna of the Vicksburg formation possesses certain distinctive characteristics, although some of the common Vicksburg forms such as *Orbitoides* and *Pecten perplanus* are also found in the underlying Jackson formation. One of the characteristic fossils of the formation is *Amusium ocalanum*. *Venericardia planicosta* which ranges up into the underlying Jackson formation has not been found in the Vicksburg formation. Common Vicksburg fossils are *Orbitoides mantelli, Orbitoides papyracea, Nummulites wilcoxi, Glycymeris arctatus, Pecten poulsoni, Pecten perplanus, Amusium ocalanum*, and *Cytherea sobrina*.

Areal distribution.—The Vicksburg formation underlies a large area in the western part of the Coastal Plain, including parts of or all of the counties of Sumter, Lee, Terrell, Webster, Randolph, Clay, Early, Calhoun, Dougherty, Baker, Mitchell, Miller, and Decatur. Areas also occur in Crisp, Dooly, Houston, Pulaski, Twiggs and Laurens counties. Eastward from Oconee River the formation has been largely concealed by later formations and only small areas are known in Screven and Burke counties. With the exception of the Altamaha (Lafayette?) and Pleistocene surficial deposits, the area over which the Vicksburg is the surface formation is greater than that of any other Coastal Plain formation.

Physiographic expression.—The formation has exerted a notable effect upon the topography. The general surface areas underlain by it are more nearly level than is usual in the case of the other older Coastal Plain formations. Underground solution has been extensive and the plains are dotted by limesinks and ponds. These ponds vary from shallow, circular depressions not more than 50 feet across, to sinks occupying several hundred acres. The region is also characterized by a scarcity of surface streams tributary to the larger streams since much of the drainage is underground by way of the sinks.

Structure.—The beds are almost horizontal, but dip slightly to the southward, at an angle less than that of the underlying older strata. Estimating from the supposed base of the formation at Americus and Cuthbert, and the supposed base at Albany as determined from the record of an artersian well, the dip southward probably does not exceed eight feet per mile. No flexures or faulting were observed at any place, although detailed geologic work may reveal disturbances of this character; it is certain that the Coastal Plain has undergone oscillations subsequent to the deposition of the Vicksburg formation.

Economic geology.—The Vicksburg formation contains at a few places beds of hard, comparatively pure limestone, suitable for lime-burning. The most suitable rocks of this character noted during field work are near Armena, Lee County, and on the Jones plantation three miles west of Arlington; similar rocks, however, doubtless exist at other localities. The harder phases of the limestone are also suitable for road metal when surfaced with flint; such material has been used for this purpose with some success at Albany. The flint rock of the formation may be used locally for road metal and in concrete work. Most of the more important hard rock exposures of the formation are mentioned on succeeding pages.

LOCAL DETAILS

CHATTAHOOCHEE RIVER

On Chattahoochee River, the Vicksburg formation appears at Miriam Landing, Decatur County, and is described by Langdon[1] as a white orbitoidal limestone, having a thickness of 200 feet.

At Saffold, Georgia, and Alaga, Ala., beds of flint containing Vicksburg fossils appear in the escarpment of the second Pleistocene terrace at an elevation of 50 to 75 feet above river level. Limestone occurring near the river level at the Atlantic Coast Line railroad bridge, is probably referable to the underlying Eocene, and has been previously discussed.

BETWEEN FLINT AND CHATTAHOOCHEE RIVER

Much of the region between these rivers is a nearly flat plain in which limestone exposures are rare. The surface materials consist of red, argillaceous sands, for the most part residual, in which are embedded fragments of flint that contain the same fossils as the limestone of the formation as exposed on Flint River.

Cuthbert, Randolph County.—Residual boulders of flint are numerous over the surface west and southwest of Cuthbert; the rock is in part hard and vitreous and in part soft and porous. In a cut of the Central of Georgia Railway, one and one-half miles west of the station, fossiliferous Vicksburg flint in clay rests unconformably upon red sand which is supposed to be Claiborne (see page 266.) At one place there is a pocket of laminated, lignitic clay in the Vicksburg formation. The flint at this locality contains *Orbitoides, Pecten perplanus, Cytherea sobrina,* and other Vicksburg forms.

Blakely, Early County.—Dr. Vaughan has furnished the following notes on the geological conditions at Blakely:

[1]Report on the Coastal Plain of Alabama: Geol. Survey of Alabama, 1894, p. 745.

"The surface is composed of red sands, underlain by Vicksburg limestone changed to chert. *Orbitoides mantelli* (Morton) is very abundant and an apparently undescribed species of Pecten was obtained."

Prof. S. W. McCallie[1] has published the record of a deep well at Blakely.

Blakely Deep Well, Blakely, Ga.

				Feet
Red, sandy clay	from	1	to	10
Coarse, grayish sand	"	10	"	20
Coarse, light-yellow sand	"	20	"	30
Yellowish, cherty limestone (Vicksburg)	"	30	"	40
Yellowish, or grayish, sandstone	"	40	"	50
Light-colored, almost white calcareous sandstone probably base of Vicksburg-Jackson	"	50	"	70
Gray sands, darker at bottom	"	70	"	140
Greenish sands, with *Ostrea divaricata*	"	140	"	160
Fine, gray sand, hard ledge at bottom	"	160	"	285
Fine sand, with some clay	"	285	"	290
Bluish clay	"	290	"	490
Quartz sand, with glauconite	"	490	"	500
Hard sandstone with glauconite; two oysters apparently *Gryphaea* and *Exogyra costata*	"	500	"	510
Grayish or bluish sands	"	510	"	580

From 580 feet to the bottom of the well, limestone interstratified with clays and sands is reported. The third water-bearing stratum, which is probably upper Cretaceous, is said to consist of a coarse sand.

The flint from the Vicksburg formation in this vicinity has been used for macadamizing the streets of Blakely.

Hilton, Early County.—In a railroad cut one mile west of Hilton Station, 20 feet of white, siliceous clay of the Vicksburg is exposed, overlain unconformably by coarse, pebbly sand, probably a Pleistocene terrace deposit. The residual, siliceous clay probably originated from the decomposition of a partially silicified argillaceous limestone. It lies near the base of the formation.

Dawson, Terrell County.—Interesting occurrences of the Vicksburg formation are revealed in a cut of the Central of Georgia Railway one-half mile east of the station. Soft, porous, or "rotten" flint occurs in mottled, residual, siliceous clay, but there are layers of coarse, purplish, red, and yellow sand, and pockets of clay, which apparently are original and not residual.

Bronwood, Terrell County.—Flint fragments of the Vicksburg formation are especially abundant in the fields, three to four miles northeast of Bronwood. These are evidently near the base of the formation.

[1]Bull. Geol. Survey of Georgia No. 15, pp. 105-107.

A. MASSES OF FLINT FROM THE VICKSBURG FORMATION, EIGHT OR NINE MILES ABOVE BAINBRIDGE, DECATUR COUNTY.

B. EXPOSURE OF FLINT AND LIMESTONE OF THE VICKSBURG FORMATION JUST ABOVE DEWITT FERRY, FLINT RIVER, MITCHELL COUNTY.

Arlington, Calhoun County.—There is a notable outcrop of limestone near Arlington. The rock appears in a bluff on the edge of the swamp of Spring Creek, on the T. F. Jones plantation, three and one-half miles west of Arlington. The natural exposure shows a maximum of 20 feet, of very compact, white, crystalline limestone. The purity of the rock is exceptional and it is exceedingly hard and compact, whereas the formation elsewhere is generally soft. Crystallization of the calcium carbonate has probably largely destroyed fossils, but *Orbitoides, Pecten, and* Bryozoa were detected, though no species were determined. The fossils and the geographic position of the outcrop seem to be sufficient evidence of its Vicksburg age.

There is a conspicuous occurrence of Vicksburg flint in a cut of the Central of Georgia Railway two miles west of Arlington. The flint is embedded in a bluish red and mottled, siliceous clay.

Colquitt, Miller County.—Flint in the form of large projecting boulders is exposed on Spring Creek, one-half mile west of Colquitt, and on Long Branch, two and one-half miles north of Colquitt. At each place the rock is porous and tripoli-like, a condition probably due to a partial replacement of limestone, the remainder being carried away in solution. Casts and moulds of *Pecten, Orbitoides,* small gastropods, and a large oyster are numerous.

Andersonville, Sumter County.—Exposures of stratigraphic interest occur on the Battle plantation, five miles southeast of Andersonville, and near the ninth milepost on the lower Americus-Oglethorpe road. The following succession occurs:

Section on Battle plantation.

	Feet.
Oligocene.	
Vicksburg formation.	
8. Knoll of hard, vitreous flint with Vicksburg fossils	
7. Red, argillaceous sand	
6. Thin flint layer with the fossils, *Orbitoides, Pecten*, etc	30
5. Red sand	
4. Yellow, sandy, glauconitic clay	12
3. Thin layer of quartzite	2
2. Purplish sand	4
(Unconformity)	
Eocene.	
Claiborne group ?	
1. Fine, incoherent, quartz sand	10+

The base of the Vicksburg here contains a small amount of lignitic matter. The Vicksburg-Claiborne unconformity is also revealed near the seventh milepost on the Americus-Oglethorpe road.

Americus, Sumter County.—In this vicinity flint fragments are abundant in the soil and are prominently exposed in a cut of the Seaboard Air Line Railway three miles west of Americus. Vicksburg flint also occurs south and east of Americus. In the city of Americus, the Vicksburg formation consists of deep red argillaceous sand capping the higher land and resting unconformably on non-fossiliferous sand believed to belong to the Claiborne group. This unconformity is revealed in a cut one-quarter of a mile east of the Seaboard Air Line Railway station.

Armena, Lee County.—A fine exposure of Vicksburg limestone occurs on the plantation of Mr. J. F. Cocke, at Armena, 11 miles northwest of Albany. About three-quarters of a mile northeast of the station 10 feet of the rock appears in a bluff of Fowltown Creek, and about one-quarter of a mile east of this latter locality, at a cave known as the "Indian Den," there is 18 feet of limestone. The limestone is overlain by a small thickness of red, residual sand, containing scattered flint fragments. The rock at both localities is a hard, white, crystalline limestone in massive beds; it is of sufficient purity to make it a valuable stone for the manufacturing of lime. The fossils, *Orbitoides, Operculina, Pecten perplanus,* and *Amusium ocalanum,* were collected here. The rock is correlated with the Vicksburg limestone at Albany and at other points on Flint River.

Palmyra, Lee County.—A fine exposure of Vicksburg limestone also occurs on Fowltown Creek, at Davis's Mill near Palmyra, six miles north of Albany. The limestone is soft, contains *Orbitoides, Pecten,* Bryozoa, etc., and resembles that at the power plant north of Albany. A maximum of 30 feet of rock is exposed and it is overlain by dark red sand.

EXPOSURES ON AND NEAR FLINT RIVER

The most typical exposures of the Vicksburg formation occur along Flint River. For an airline distance of about 80 miles the channel of the river is entirely cut in the Vicksburg formation.

Near Oakfield, Worth and Lee Counties.—Limestone is exposed at the Albany & Northern Railroad bridge over Flint River, and in the bluff on the southern side of the Great Bend of the river, one and one-half miles above the bridge, in Lee county. The rock contains characteristic Vicksburg fossils, such as *Orbitoides, Pecten,* etc. A minute, curled foraminifera, *Operculina,* is especially abundant.

One and one-half miles above the bridge a precipitous bluff 25 to 50 feet high exposes at its base 10 or 15 feet of white, compact, non-crystalline limestone. The rock presents a jagged and pitted appear-

ance and the river has cut cave-like recesses into it. The strata overlying the limestone consists of red, argillaceous sand containing flint fragments, doubtless residual, above which is a variable thickness of Pleistocene terrace sand. This locality was described by Spencer as the southern limit of the Claiborne group, but paleontologic evidence establishes its Vicksburg age.

The limestone probably extends up the river above Oakfield to a point a short distance above the Seaboard Air Line Railway bridge. The rock exposed in the river bank at this latter place, and at Clegg's siding a short distance to the eastward, resembles the Vicksburg limestone. The fossils noted were *Orbitoides, Pecten perplanus* Morton, and Bryozoa. The possibility, however, of its being the equivalent of the Jackson limestone south of Perry should be considered.

Dr. Vaughan furnishes the following geologic notes on eastern Lee County and western Worth County:

"At Philema, Ga., there is a well 163 feet deep with a flow of good water. I could not get a reliable record of the well, but apparently the water comes from the Vicksburg limestone.

"There are numerous sinkholes four miles west of Philema. The subsurface rock is a soft, porous, often reddinsh-stained limestone, sometimes silicified. Orbitoides is abundant. This rock apparently belongs to the Vicksburg formation.

"Specimens of limestone were obtained from a well four and one-half miles west of Philema at a depth of about 30 feet.

"Topographically, the country from Flint River about two miles above Philema, to four miles west of Philema, is 'flat-woods,' very level, and probably does not rise more than 50 feet above the river for several miles back. About four miles west of the river there are numerous limesinks in which are deep ponds or pools. The surface formation consists of reddish sands or reddish sandy clays in which chert is abundant. It is probable that much of the clay is residual. The elevation of this area is higher above the river than that of the 'flatwoods.' According to the best information obtainable, the surface sands and clays are from 30 to 50 feet thick. These are underlain by limestone, the thickness of which could not be positively ascertained. According to some informants the thickness of the limestone is about 50 feet, below which there is a sand bed. However, limestone certainly occurs to a depth of about 160 feet on James Martin's place, four or five miles southwest of Philema. When I visited this place a well was being bored and the boring had reached about 160 feet, and was at that time in limestone containing *Orbitoides*. This place is estimated to be 75-100 feet above Philema. A bed of sand had been penetrated, but the driller did not wish to give a detailed record.

"In going down Flint River from Philema to Albany, a distance by river of 30 to 50 miles, outcrops of limestone were seen from place to place from a few miles below Philema entirely to Albany. The rock is yellowish or whitish, often indurated on exposed surfaces, and belongs to the Vicksburg formation. About a mile below the mouth of Mill Creek is an exposure of blue sandy clay, aparently alluvial, but very different from the usual alluvium.

"The structure is extremely simple, the beds frequently showing no perceptible dip, but occasionally showing a dip slightly greater than the fall of the river. No marked flexures were observed, but at one place there were slight undulations of the strata over a distance not exceeding 100 or 200 feet."

"Fossils were collected in Lee County as follows:

List of fossils from Lee County.

Four miles west of Philema, Lee county, Ga.

Orbitoides mantelli (Morton)
Echinoid
Scaphander sp.
Pecten perplanus Morton

Four and one-half miles south of east of Philema, out of a well 40 feet below surface.

Pecten (Chlamy cf. indecisus Dall)
Amusium ocalanum Dall

Thirty feet below surface:

Operculina complanata (Defrance)
Operculina complanata var. granulosa Lymeriea

Albany and vicinity.—Limestone and flint of the Vicksburg formation appear at a number of localities along Flint River in the vicinity of Albany. The country to the west of Albany is covered by a red, argillaceous sand, and limestone is rarely seen, though there is abundant evidence that it is the underlying formation. The best locality for studying the limestone is at the power plant on Kinchafoonee Creek two miles north of Albany. A large amount of rock has been excavated in constructing the dam at this place, and the bluffs of the creek also present a good section.

Section on Kinchafoonee Creek two miles north of Albany.

	Feet
4. Pleistocene sand, flint fragments at the base	10
Vicksburg formation.	
3. Limestone	5
2. Nodular and discontinuous flint layer; may reach a thickness of	2
1. Massive limestone	8

The limestone here is, on the whole, white or cream colored, soft, some parts friable, and massive bedded. It contains flint which seems to be both a replacement of limestone and also a jasper, which may be due to the segregation of silica and not to replacement. The abundance of remains of marine life is notable, the rock in places being composed almost entirely of a friable mass of Bryozoa and shells.

The following notes on the Vicksburg formation in the vicinity of Albany are furnished by Dr. Vaughan:

"At the crossing of the Albany Northern Railroad over Muckafoonee Creek there is an exposure of whitish, soft, chalky limestone stained yellow in places, containing an abundance of poorly preserved fossils.

"On the east side of Flint River opposite Albany, there is an outcrop of white limestone which is in places silicified. *Orbitoides* and *Pecten poulsoni*

are abundant. This material seems to belong to the Ocala limestone division of the Vicksburg. The limestone is overlain by red sands and clays which form the surface.

"At the springs about 3 miles south of Albany an enormous volume of water comes to the surface through channels in the Vicksburg limestone. Specimens of *Amusium ocalanum* Dall, echinoid spines, and Bryozoa were collected at this locality. I did not see any *Orbitoides*.

"At Rock Hill about one and one-half miles west of Albany on the road to Dawson (not the main road) a spring issues from the limestone. The limestone is in places cherty with numerous *Orbitoides* and *Pecten*, apparently *poulsoni*.

"About three miles west of Albany there is a rise of some 30 feet and a change in surface soil from grayish sands to red, sandy clay.

"Thirteen miles west of Albany at Providence plantation yellow limestone and chert occur in brownish and reddish sands. *Orbitoides* and *Pecten* were collected.

"About a mile south of Providence plantation a specimen of a làrge *Pecten* was obtained.

"The following are lists of fossils collected in the vicinity of Albany:

Fossils from Albany and vicinity.

Three miles west of Albany, Ga.

Monoporella—a species common in the Vicksburgian Oligocene, and until now found in collections from no other horizon. Determined by R. S. Bassler.

Just above bridge of Albany Northern Railway over Muckafoonee Creek.

Operculina
Cidaris
Macropneutes?
Amusium ocalanum Dall.

Western end of railroad bridge at Albany, Ga.

Orbitoides mantelli (Morton)
Lyria costata (Sowerby)
Orthaulax? sp.
Pecten perplanus morton
Crassatellites mississippiensis (Conrad)
Venus sp.

Albany, Ga., western end of wagon bridge.

Orbitoides mantelli (Morton)
Orbitoides papyracea Boubée
Nummulties wilcoxi Heilprin.

Muckafoonee Creek, Albany, Ga.

Operculina complanata (Defrance).

Prof. S. W. McCallie[1] has published the record of a deep well at Albany which is here repeated:

Log of City Artesian Well, No. 2. (Albany, Ga.)

Bored by Mr. E. F. Joyce. *Log by Mr. C. W. Tift.*

		Feet.		
Red clay	from	0	to	20
Light-colored clay	"	20	"	23
Coarse sand (Vicksburg)	"	23	"	25
Light-colored clay and coarse quartz sand	"	25	"	35
Limestone, *Orbitoides*, at 150 feet, and from 190 to 200 feet	"	35	"	200

[1]Geol. Surv. Ga., Bull. 15, 1908, pp. 98, 99.

				Feet
Gray limestone, *Orbitoides*, echinoids, *Bryozoa*, *Terebratula;* some shale from 230 to 240 ft.	"	200	to	280
Gray sand with comminuted shells (*Ostrea*) . . .	"	280	"	285
Some shale, coarse sand, shells and sharks' teeth at				311
Hard layer, *Ostrea divaricata*	"	318	"	320
Ostrea divaricata at				320
Ostrea alabamiensis at				340
Shale or marl, water vein at				350
Ostrea divaricata and *alabamiensis* at				363
Bed of lignite at				367
Bed of lignite at				400
Sand	"	400	"	475
Echinoid spines, lamna teeth, stiff blue clay	"	470	"	475
Stiff blue clay	"	475	"	480
Hard gray sandstone	"	485	"	488
Oligocene and Eocene from the surface to				500
Pyrite and small oysters at				520
Green sands and greenish micaceous shales	"	530	"	540
Gray sand with black particles at				600
Water-bearing horizon, limestone, with pieces of hard, gray sandstone between 785 and 790 . .	"	690	"	790
Hard rock	"	790	"	800
Clay shales, with limestone between 835 and 840 .	"	800	"	850
Limestone and shales	"	850	"	890
Chiefly sand, at top a little gravel. At 880 feet limestone or calcareous sand, also light gray micaceous sand; at 890 feet, grayish sand, calcareous fragments, hard, black pieces of pebbles and Ostrea, water-bearing micaceous sandstone between 920 and 930 feet		890	"	940
Blue micaceous clay at 950 feet, thick shelled oysters, *Gryphaea*, the same also at 1,080 feet; at 1,100 feet gray sand with *Ostrea* and *Exogyra costata*		940	"	1,100
Stiff, blue clay, micaceous sandstone, oysters . . .		1,100	"	1,200
Very stiff blue clay, at 1,255 feet, streaks of sand and shells, a small flow of water; from 1,240 to 1,260 soft, shiny, blue clay		1,200	"	1,260
Marl, gray sand, sandstone lumps, shells		1,260	"	1,270
Gray and black sand, sandstone lumps		1,270	"	1,310
Black irregular, waterworn pebble, with hard crystalline fracture; coarse and fine quartz sand, shells, decayed wood, third water-bearing stratum; 50 gallons per minute		1,310	"	1,315
Well ends in quartz sand at				1,320

The base of the Vicksburg formation according to this section is probably between 200 and 280 feet, and the base of the Eocene is probably above 940 feet, since according to fossils the strata between 940 and 1,100 feet are Cretaceous. Dr. Stephenson has made a recent examination of the fossils obtained from the borings of this

well and reports the Cretaceous fossils *Anomia argentaria,* at 890 feet, and *Exogyra costata (?)* at 500 feet.*

Nigger Head Bend, Mitchell County.—This locality is about one and one-half miles south of Hardaway and on the east side of Flint River. The bluff at this place has a maximum height of 30 feet at low water. White limestone of the Vicksburg formation appears at the base of the bluff.

Section at Nigger Head Bend

	Feet.
Pleistocene.	
4. Stiff, bluish clay, which weathers yellowish or brown, variable in thickness	4
3. Yellow, gray, and brown stratified sand; has a layer of pebbles at the base	8
(Unconformity)	
Oligocene.	
Chattahoochee formation.	
2. Drab, bluish, and purplish stiff clay, having embedded in it fossiliferous flint fragments; the whole appears to be residual	15
Vicksburg formation.	
1. White or gray pitted limestone; appears both lithologically and paleotologically similar to limestone at Albany	2

From paleontologic evidence Dr. Vaughan has classed stratum No. 2 as Chattahoochee.

Dewitt, Mitchell County.—Soft, gray or white marl appears near the boat landing about three-quarters of a mile northwest of Dewitt. This rock rises about three feet above low water. It contains *Orbitoides* and the characteristic Ocala limestone fossil, *Amusium ocalanum.* Small fragments of bones were also noted. Flint boulders, probably resulting from the silicification of the limestone, were observed.

Newton, Baker County.—Both limestone and flint appear in the bluffs of Flint River in the vicinity of Newton. The lithologic and paleontologic appearance of the rock is similar to that at Bainbridge. A thickness of three or four feet of limestone appears in the bed of

*NOTE.—Dr. Stephenson has, in his study of the log of this well, placed the top of the Cretaceous at 500 feet. (See page 200.) This leaves a possible thickness of only about 220 feet for the combined Eocene. Based on observations over the belts of outcrop, the thickness of the Claiborne formations has been estimated at 250-300 feet on Chattahoochee River and at or near the same thickness on Flint River; that of the Wilcox formation at 150 feet; that of the Midway formation from 218 feet on the Chattahoochee to 400 feet on the Flint. The thickness of the Jackson is small, but will probably increase considerably the total for the Eocene. If the top of the Cretaceous is at 500 feet in the Albany well section, then there is a surprising decrease in the thickness of the Eocene southward from the belts of outcrop.—O. V.

Cooleewahee Creek; it is a brownish, soft, somewhat granular, and oölitic rock containing Vicksburg fossils which Dr. Vaughan identifies as:

Fossils from Cooleewahee Creek.

Operculina complanata	Nummulites wilcoxi
Orbitoides mantelli	Amusium ocalanum

Excellent exposures of flint were found at Bagg's Ferry, five miles below Newton. The flint is fossiliferous and is evidently a silicification and replacement of limestone. All degrees of silicification were noted, from soft, white, siliceous limestone to vitreous, dense, translucent flint. The greater part of the rock is a soft, white porous flint. Huge blackened fragments appear in the channel of the river and form a picturesque scene.

At Red Bluff, seven miles above Bainbridge, a limestone similar to the rocks exposed at Bainbridge appears in the bluff 25 feet above low water. The fossils furnish evidence that the residual flint overlying the limestone at this place belongs to the Chattahoochee formation. (See pages 325, 329.) The limestone presents an uneven upper surface due to solution and decay, and presents protrusions in the residual sandy clay.

The following fossils were collected from the limestone and identified by Dr. Vaughan:[1]

Fossils from Red Bluff.

Orbitoides papyracea (Boubée)	Cassidulus sp.
Orbitoides n. sp. (stellately marked form)	Clypeaster sp.
	Pecten suwanneensis Dall
Nummulites wilcoxi Heilprin	Pecten indecisus Dall
Echinolampas sp.	Amusium ocalanum Dall"

Further references to the Vicksburg formation along Flint River will be found in the chapter on the Chattahoochee formation.

Bainbridge.—Limestone of the Vicksburg formation is exposed in the bluff on the west side of the river at Bainbridge, between the wagon bridge and the Atlantic Coast Line Railroad bridge. The river bluff here is about 20 feet high. The section is as follows:

[1]The foraminifera in this list were identified by Dr. R. M. Bagg.

Section at Bainbridge.

	Feet
Pleistocene ?	
3. Brown sand and clay	8
(Unconformity)	
Oligocene.	
Vicksburg formation.	
2. Gray or bluish residual clay	2
1. Soft limestone, maximum thickness	10

The limestone rises 10 feet above low water. It is white or gray in color, massive, and shows no bedding. Near the water's edge it has a pitted, vesicular appearance. The rock is very soft, has a granular appearance, and is in places merely a loosely compacted mass of foraminifera and pectens. Brown, limonitic clay occurs at the top of the limestone. This latter material also appears at Blue Springs and Red Bluff. Soft limestone is also exposed on the left bank of the river between the wagon bridge and the Georgia, Florida, & Alabama Railroad bridge, and may be seen in the low bluffs of the river at a number of points below Bainbridge. At Blue Spring, four miles below, it is overlain by the coralline flint of the Chattahoochee formation.

The following notes on the strata at Bainbridge were supplied by Dr. Vaughan:

Section of bluff on east side of Flint River, back of old factory, about two miles above Bainbridge.

	Feet.	In.
Pleistocene.		
3. Reddish sands and reddish sandy clay mixed with some blue clay	15	
Oligocene.		
Chattahoochee formation.		
2. This stratum presents diverse characters:		
a. Lower end of bluff along Vicksburg contact,—the material consists of whitish clay, sometimes slightly sandy, and blotched with vermillion. In the clay are pockets of limonitic iron ore. The clay occurs in the iron ore, on its sides, and beneath it. In the iron carbonaceous particles were found. At the lower end of the bluff is 10 feet or more of this clay and limonite.		
b. Face of bluff proper,—impure lignite, and blackish lignitic clay, 5 feet. This is a pocket not extending to the lower end of the bluff and is replaced by purplish and bluish clays. Bluish clays, more sandy at top, overlie the lignite and lignitic clay	17	6

Vicksburg formation.

1. The lowest stratum seems to be that seen at the lower end of the bluff. It is a yellowish, argillaceous limestone, sometimes hard and sometimes soft and granular, composed of the remains of various calcareous organisms which show signs of trituration. Fossils are abundant but the species are few. *Amusium ocalanum* Dall and a very large *Orbitoides*, *O. papyracea* Boubée, are the commonest. This stratum has evidently suffered great loss by solution, also the upper surface is extremely irregular. The thickness at one place, at the bottom of which is limestone, is fully 15 feet. In places the limestone appears as dike-like masses, the next stratum or its derivations being plastered against the sides.

"The total height of this bluff is 37 or 38 feet. The lignitic stratum is also seen upstream from the bluff in the river bank. In this stratum were found large pieces of lignitized wood.

"The upper surface of the Vicksburg frequently rises much above the level of the base of the next higher formation, but where contacts could be found the Vicksburg passes below it. It seems that the Vicksburg has been sub-aerially eroded. Another possible explanation is that the irregular surface is due to the underground solution of the limestone. The latter hypothesis is discarded and the former accepted because of the sudden change in the lithologic character of the next higher stratum.

"Westward from Bainbridge the limestone does not appear at the surface and the formation is represented by fragments of flint, which bear the characteristic fossils of the Vicksburg formation. Limestone, however, is encountered in wells at varying depths."

Brinson, Decatur County.—Large residual masses of flint occur in the pine woods on the west side of Spring Creek. The rock contains *Orbitoides papyracea, Amusium ocalanum*, etc.

BETWEEN FLINT AND OCMULGEE RIVERS

Elko, Houston County.—There is a well-known occurrence of flint in the railroad cuts one mile south of Elko. The flint appears as massive fragments of compact jasper, breaking with a sharp, splintery, conchoidal fracture, and also as friable, very fossiliferous masses in red clay. The locality is of stratigraphic interest, and the flint and clay may be of economic value for road metal.

At Taylors Ford, four miles south of Elko, on the Unadilla road, fossiliferous flint fragments embedded in red and yellow clay are prominently exposed. A collection of Vicksburg fossils was made near this locality by S. W. McCallie.[1]

OCMULGEE RIVER

Hawkinsville, Pulaski County.—The Vicksburg formation near Hawkinsville consists of soft, white, fossiliferous limestone, contain-

[1]Underground waters of Georgia: Geol. Survey of Georgia, Bull. No. 15, 1908, p. 352.

ing abundant fossils, together with fragments of fossiliferous flint embedded in residual clay. Exposures occur in the river banks near the city, at Harrells Landing, McDonnells Landing, Ways Landing, and Taylors Bluff, three miles above Hawkinsville. The formation has a similar lithologic and paleontologic aspect to that farther west. The section at Taylors Bluff is of much stratigraphic interest, since the relation of the Vicksburg formation to the Jackson formation are shown. (For section see page 305.)

Fossils collected from the lower 20 feet are regarded by Dr. Vaughan at Jacksonian in age; at 22 feet from the base of the bluff the characteristic Vicksburg fossil, *Amusium ocalanum,* was collected. No unconformity or break in sedimentation was observed between the formations.

OCONEE RIVER.

Dublin, Laurens County.—Gray, brown and white, both porous and vitreous, compact flint rock, appears as residual remnants at a number of localities along Oconee River. The following fossils were obtained from the rocks thrown from an excavation for a reservoir at the pumping station of the city water works:

Fossils from Dublin.

Cassidulus sp.	Pecten poulsoni Morton
Scutella sp.	Pecten perplanus Morton
Glycymeris arctatus (Conrad)	

There are no natural exposures of the limestone of the Vicksburg formation at Dublin, although it is encountered in wells.

EXPOSURES ON AND NEAR SAVANNAH RIVER

Girard and Flint Branch, Burke County.—Flint, bearing Vicksburg fossils, outcrops at Buxton's Mill, two and one-quarter miles south of Girard, and on the Millhaven public road at the ford at Mill Branch, two and one-half miles a little east of south of Girard. This shows that the Claiborne has dipped beneath the cover of the younger formations at this point. There is residual red sand over the Vicksburg formation resembling that of the Barnwell sand, rendering the precise location of boundaries difficult or even impossible.

At Ellisons Bridge, three miles southwest of Girard, vitreous flint forming a bluff 10 feet high is exposed a short distance above the bridge on the west side of Briar Creek. No determinable fossils were found and it is not possible to determine whether the rock belongs to the Claiborne group or to the Vicksburg formation.

Fragments of flint appear along Flint Branch, one and one-half miles north of Stony Bluff, Savannah River, which contain a few imperfect prints and casts of fossils. Doctor Vaughan identified *Orbitoides* from this locality.

Johnsons Landing.—At Johnsons Landing, Savannah River, S. C., flint rock appears near the level of the river, a short distance below the landing, and also as residual fragments in the escarpment of the second terrace. The rock is white, and porous, and is similar in appearance to much of the flint in the Vicksburg formation along Flint River. *Pecten, Orbitoides,* and corals were noted. This rock is included in Sloan's[1] "King's Creek Phase" of the Oligocene.

Hershman Lake, Screven County.—Large fragmental blocks of flint, as much as three feet in thickness, were discovered at the western end of Hershman Lake. The rock appears similar to that at Johnsons Landing and is doubtless of Vicksburg age. No outcrops of the formation of Vicksburg were found in the river bluffs below this point.

Millhaven, Screven County.—An exposure of flint rock, which may be the equivalent of the flint of Vicksburg age on Savannah River occurs on Briar Creek a short distance above the bridge at Millhaven, or Garnett. It is very poorly fossiliferous, however, and it is difficult to determine its stratigraphic position beyond question. A small echinoid, *Orbitoides (?)*, and a few poorly preserved siliceous bivalve casts were the only fossils found.

APALACHICOLA GROUP

CHATTAHOOCHEE FORMATION

NAME

The name Chattahoochee is applied to a limestone formation intervening between the Vicksburg and Alum Bluff formations. The name was first applied by D. W. Langdon[2] to a group of beds lying between the Vicksburg or "Orbitoidal" limestone, on Chattahoochee River, and the upper beds at Alum Bluff, Apalachicola River, 25 miles below River Junction, Fla. The age of the beds was given as "newest Eocene" or "oldest Miocene," since the Oligocene equivalence of the fauna was not at that time recognized. The Chattahoochee group as described by Langdon probably included beds which are now referred to the Alum Bluff formation, as the *Pecten* he mentions can scarcely be other than *Pecten madisonius* var. *sayanus* Dall, an Alum Bluff fossil.

[1]Catalogue of Mineral Localities of South Carolina: Geol. Survey of South Carolina, p. 464.
[2]Amer. Jour. Sci., 3d ser., vol. 38, 1889, p. 324.

Notes on the formation in Georgia have been published by Pumpelly,[1] Foerste,[2] Spencer,[3] Vaughan,[4] Harper,[5] and McCallie.[6] It is evident that in much of the previous literature, beds which are described in this report under Alum Bluff formation, have been included under the name Chattahoochee "beds," "series," or "group" as used by various writers. The name Chattahoochee, as now used, is restricted to the lower portion of the Chattahoochee group of Langdon.

DEFINITION

Stratigraphic Relations.—Pumpelly[7] and Vaughan[8] have recognized an erosion unconformity between the Chattahoochee and the underlying limestone of the Vicksburg formation in Decatur County. At Blue Springs on Flint River, four miles south of Bainbridge, both formations are present, but the contact between the two is much obscured by the weathering of both the Vicksburg and the Chattahoochee.

At Red Bluff, seven miles north of Bainbridge, an exposure similar to that at Blue Springs occurs. The Chattahoochee formation appears as fragments of flint in residual, sandy clay, and the weathered limestone of the Vicksburg formation appears at the base of the bluff. There is evidence at this locality, and also at the bluff back of the Old Factory about two miles above Bainbridge (see p. 321), of an erosion unconformity. However, at Forest Falls, eight miles northwest of Whigham, no unconformities were observed in a section the base of which, according to paleontologic evidence, is referable to the Vicksburg formation, and successively higher portions of which, on the same kind of evidence, belong to the Chattahoochee and Alum Bluff formations.

There was probably continuous deposition from the beginning of Chattahoochee deposition to the end of Alum Bluff deposition. No evidence of any time interval between the deposition of the two has been observed in the field. Prof. McCallie,[9] however, has noted an unconformity at the old Toy phosphate pit, three and one-half miles west of Boston, but whether this is an erosion unconformity or one due to the solution and irregular weathering of the limestone

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[1]Amer. Jour. Sci., 3d ser., vol. 46, pp. 445-447.
[2]Amer. Jour. Sci., 3d ser., vol. 48, 1894, pp. 41-54.
[3]Report of Progress: Geol. Survey of Georgia, 1890-1891, pp. 57-59.
[4]Science, n. s., vol. 12, 1900, pp. 873-875.
[5]Annals New York Acad. Sci., vol. 17, pt. 1, 1906, p. 17.
[6]Underground waters of Georgia: Geol. Survey of Georgia Bull. No. 15, 1908, p. 32.
[7]Op. cit., pp. 445-447.
[8]Op cit., pp. 873-875.
[9]Geol. Survey of Georgia Bull. No. 5-A, 1896, p. 62.

has not been determined. When this locality was visited the relations of the clay to the limestone were obscure because the pits had become largely filled by debris.

Lithologic Characters.—The Chattahoochee formation is in general calcareous and varies from compact, pure, crystalline limestones to earthy and argillaceous limestones, and calcareous sands and sandstones. Compact gray, drab, or white, fossiliferous limestones make up the bulk of the formation. A brecciated or conglomerate structure is characteristic of some of the beds. This phenomenon was observed at nearly all localities where there were good exposures. These conglomerate beds do not seem to be confined to a particular horizon, and their origin and significance are not well understood. Both the matrix and the angular or rounded fragments are limestone. Some beds appear to be pseudo-conglomerates, and consist of fossil echinoids in a limestone matrix, the structure of the echinoids having been partially obliterated, giving the appearance of waterworn fragments. The rock is phosphatic in a number of places, containing brown or black rounded pebbles of phosphate or fragments of bones and teeth. The limestone at the base of the formation has in a number of localities been replaced by silica; while in other instances the base of the formation is represented by fragmental beds of flint, containing corals and other fossils, in a matrix of residual clay. The flint closely resembles that of the underlying Vicksburg formation and can not always be easily distinguished from it.

Thickness.—In the gorge northwest of Faceville, Decatur County, the Chattahoochee formation has a probable total thickness of 100 feet. At Forest Falls, or Limesink, in the northern part of Grady County, it has an exposed thickness of 60 or 65 feet. No very reliable data are at hand for estimating its total thickness to the eastward and northeastward, under the cover of later formations. It is not great, however, and the maximum probably does not exceed 200 or 250 feet. Examination of borings from wells at Valdosta, Waycross, and Savannah indicate such a thickness, but the probability of a part of the limestone penetrated in these wells belonging to the underlying formation must be considered.

Paleontologic Characters.—Although there is no abrupt faunal break between the Chattahoochee and the Vicksburg formations, and there are a number of forms common to both, their faunal differences are marked. The base of the Chattahoochee contains a rich coral fauna which, in the vicinity of Bainbridge, has been studied by

Doctor Vaughan.[1] In a coral reef four miles south of Bainbridge he estimated that there were between 25 and 30 species of corals, and correlated the beds with the Oligocene of Antigua. The characteristic Vicksburg species *Amusium ocalanum* does not appear in the formation; the genus *Orbitoides* is common to both the Vicksburg and Chattahoochee formations, but the Chattahoochee species are usually different from those of the Vicksburg. *Orbitolites complanata*, a foraminifera, occurs in the Chattahoochee formation, but has not been found in the Vicksburg. *Orthaulax pugnax*, a gastropod common in the Tampa formation of Florida, has been found in two localities.

Areal Distribution.—The area over which the Chattahoochee formation appears at the surface is small, as the terrane is largely concealed by the Alum Bluff and later formations. Good exposures occur along Flint River in Decatur County; and strata belonging to the formation were noted by Langdon[2] on Chattahoochee River, nine miles above River Junction, Fla. The formation appears at Forest Falls and other lime-sinks in the northern part of Grady County; in the vicinity of Metcalf and Thomasville, Thomas County, and in the beds and bluffs of Withlacoochee and Allapaha rivers near the Georgia-Florida line. It may be represented on Ocmulgee River near Abbeville and Hawkinsville by fragmentary beds and residual flint containing corals. Limestone, outcropping near Jacksonboro, Screven County, correlated by Dr. Vaughan with the Chattahoochee formation, has a small distribution along Briar Creek in Screven County. Limestone outcropping in a small area northwest of Millen, Jenkins County, is provisionally considered as a part of the same formation, but the data for this classification are admittedly very meager. Since the discovery of the Chattahoochee formation near Cordele, Crisp County, it is not improbable that further investigations will reveal occurrences on the east side of Flint River between Cordele and Bainbridge.[3]

Physiographic Expression.—In portions of Decatur, Grady, Thomas, Brooks, and Lowndes counties, where the Chattahoochee formation lies near the surface, the topography is a little more hilly

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[1] Science, n. s., vol. 12, 1900, pp. 873-875.
[2] Amer. Jour. Sci., 3d ser., 1889, vol. 38, p. 324.
[3] NOTE.—Subsequent to the completion of the work for this report an examination was made of a limestone occurring on the C. H. Spring farm, seven miles northwest of Sylvester, Worth County. This rock is very similar, both lithologically and paleontologically, to the Chattahoochee formation near Cordele and at other localities near the Florida line, and it doubtless belongs to this division of the Oligocene.—O. V.

and rugged than in other parts of southern Georgia. Lime-sinks, lakes, and ponds, due to the underground solution and consequent caving in of the limestone of the formation are notable features of the topography.

Structure.—The formation is slightly tilted southward. The dip is believed to be very low, probably not exceeding six or eight feet per mile. The top of the formation is estimated to be about 225 feet above sea-level at Forest Falls, or Limesink, and about 200 feet above sea-level near Faceville, approximately 24 miles to the southwestward. At Red Bluff, seven miles north of Bainbridge on Flint River, Dr. Vaughan has determined the presence of the Chattahoochee by fossils, and here the base of the formation can hardly be more than 15 or 20 feet above the river, while at Blue Spring, four miles below Bainbridge, the base is about 10 feet above river level. This indicates a very low dip. What is probably limestone of this formation is reached in the Savannah wells at a depth of about 250 feet; the nearest known outcrop is on Briar Creek, Screven County. This indicates a southward dip of about six feet per mile.

Local dislocations of beds, due to underground solution and consequent sinking, have been observed in Thomas and Decatur counties.

Economic Geology.—The Chattahoochee formation contains some limestone beds sufficiently pure for use in the manufacture of lime. The rock in places is a very hard, non-magnesian limestone. Lime-kilns were formerly operated at old Jacksonboro, Screven County; on the Mitchell plantation six miles east of Thomasville; and on the old Copeland plantation, about nine miles west of Sunnyhill, Thomas County, near the Florida line. The more favorable outcrops, unfortunately, are not convenient to railway lines.

The rock locally has some value as building stone for foundations, chimneys, etc., and could be used in concrete work. Both the hard and the softer, impure limestones contain, at several localities, a small percentage of phosphoric acid, which, together with the lime, or calcium carbonate, should make them of local value as fertilizers.

LOCAL DETAILS

The stratigraphic relations and the characteristic petrologic aspects of the Chattahoochee formation are described in the following detailed sections:

DECATUR COUNTY

Bainbridge and Vicinity.—Dr. Vaughan furnishes the following description of the geology along Flint River from Red Bluff, seven miles above, to Hales' Landing seven miles below Bainbridge:

A. SINK IN CHATTAHOOCHEE LIMESTONE, RECOVERY, DECATUR COUNTY.

B. SINK IN CHATTAHOOCHEE LIMESTONE, SHOWING THE LIMESTONE AT EDGE OF POND, ORIGINAL POND. THREE MILES WEST OF METCALF, THOMAS COUNTY.

"An important exposure is revealed at Red Bluff on the west side of Flint River seven miles north of Bainbridge, as the relations between the Chattahoochee and Vicksburg formations are here exhibited.

Section, Red Bluff, Flint River, seven miles above Bainbridge.

	Feet.
3. Reddish or yellowish sand and gravel with streaks of white and red clay	15
2. Bluish or whitish clay, some sand; residual masses of chert (Chattahoochee formation) 20 feet below top of the bluff.	35 to 45
1. Limestone (Vicksburg formation) 50 feet below top of bluff to water's edge	10

Detailed description of Red Bluff section:

Pleistocene.

Okefenokee formation.

4. Yelowish sands and gravel about 2 feet.
3. Sands and gravel, clay streaks, about 15 feet. In places No. 3 seems to rest on the eroded surface of No. 2. The content of considerable quantity of small gravel makes a decided difference from No. 2.

Oligocene.

Chattahoochee formation.

2. Blue clay at water's edge.
   2a. Pocket of lignitic clay containing pieces of bark and other fragmentary plant remains, about 4 feet or perhaps more in places.
   2b. Clays, succeeded by clays and sands, 42 feet. Total thickness of No. 2,—46 feet.

The basal part of No. 2 is deposited unconformably over No. 1. Several holes were dug around the limestone to determine its relation to the clays. The general characters of No. 2 are similar to those revealed at Little Horse Shoe Bend, (p. 330), and the Old Factory, (p. 321). The clays are bluish whitish, or purplish; they are sandy in the upper portion.

About 39 feet above the river is a mass of chert, probably residual after solution of the other portions of the stratum. Fossils are numerous,*Pecten*, *Glycymeris*, *Venericardia*, *Venus*, *Amauropsis*, *Cypraea*, *Xenophora*, etc. The molluscan fauna is the same as that of the chert at Little Horse Shoe Bend. *Orbitoides* is abundant, no identifiable corals collected.

Vicksburg formation.

1. The oldest rock exposed is the Vicksburgian. It is a yellowish usually soft, and often granular limestone. Fossils, mostly foraminifera, are numerous. *Orbitoides*, several species, including *O. papyracea* Boubée are abundant and attain an enormous size, several inches in diameter. There are other foraminifera, including *Nummulites*, several species of mollusks, *Cypraea* (casts), 2 species of *Pecten*, etc. This limestone is exposed at two points, where the bluff was studied and at both it extends to the water's edge. In the down river exposure its thickness is 13 feet. Two springs burst out of the limestone at the lower of the two exposures.

The stratigraphic relations of the formations are the same as at the old Factory, on Flint River, two miles above Bainbridge, (see p. 321). Masses of chert of the Chattahoochee formation were seen along the road to Bainbridge for a distance of several miles.

Bluff below Plant System Wharf, Bainbridge.—The section here outlined is similar to those at Red Bluff, Old Factory, Little Horse Shoe Bend, and Hales Landing.

Section at Bluff below Plant System Wharf, Bainbridge.

	Feet.
Pleistocene.	
4. Yellowish sands	5 to 6
Oligocene.	
Chattahoochee formation.	
3. Cherty limestone and chert as residual masses, some lines of chert in sand, from a few inches to about	3
2. Clays, whitish, yellowish, or brownish, with limonitic pockets of variable thickness, depending upon irregularities of surface of the underlying limestone	3 to 15
Vicksburg formation.	
1. Limestone, yellowish, fossiliferous; *Orbitoides*, two species of echinoids, etc. Upper surface irregular from water's edge to about	15

The eroded upper surface of the Vicksburg is probably more clearly exposed here than at any other place. Perhaps some of the ferruginous pockets may be of Vicksburg age, but of this I am not sure.

Along the western side of the road, leading up the hill to Bainbridge, a large block of the chert was seen east of the river bridge.

Section at Cherry Shoot, three miles below Bainbridge, on west side of the river.

	Feet.
3. Whitish river sand	8
2. Hard chert in boulders	8
1. Yellowish compact sands	6

This is not a good exposure.

No. 2 contains many fossils but they are siliceous casts or replacements and could not be satisfactorily cut out. Mollusks: *Pecten*, *Tellina*, *Lucina*, *Glycymeris*, *Cardium*, *Psammobia*, *Venus*, etc., *Cypraea*, *Natica*, *Ampullinopsis*, *Cassius*. Corals: *Astrocoenia*, *Stylophora*, *Orbicella*, *Porites*, etc. Corals are abundant, though not so numerous as at Little Horse Shoe Bend.

"*Blue Spring.*—This spring, also known as Russell Spring, is on the east side of Flint River, about four miles by road down the river from Bainbridge. The exposure at this locality is not so good as those subsequently to be described. On the surface are reddish sands; these are underlain by silicified corals of a coral reef, and silicified limestone containing molusks characterizing the Chattahochee formation. The base of the exposure is formed by marl and limestone of the Vicksburg formation.

"*Little Horse Shoe Bend.*—This locality is about four miles south of Bainbridge and about one-quarter of a mile below the mouth of the stream running from Blue or Russell Spring into Flint River. The river here makes a sharp east to west flexure producing an exposure at the upper or eastern end. One-half mile further down stream is another flexure, the river practically resuming its general north and south course. Along the western side of this flexure is the exposure next to be described.

Section at Little Horse Shoe Bend.

	Feet
Pleistocene.	
4. Red sand and some gravel, a little clay in upper part	8

Oligocene.
Chattahoochee formation. Feet.
3. Cherty limestone, a fossil coral reef. Mollusks, *Cypraea*, *Conus*, *Clavella*, *Pecten*, *Glycymeris*, *Venus*, numerous corals, *Stylophora*, *Astrocoenia*, *Orbicella*, *Siderastrea*, *Alveopora*, &c. No *Orbitoides* was found. This is not a connected stratum, but occurs in large detached masses which usually roll down the hillside; some however, are in situ. Thickness inferred from that of the larger masses 3

Probably basal Chattahoochee.
2. Bluish or whitish sandy clay containing large ferruginous segregations of limonitic character. Thickness . . . . 4 to 5

(Unexposed about six feet, but probably entirely composed of the same material as No. 2. There is some ferruginous material also some material similar to No. 1.)

Vicksburg formation.
1. Yellowish clay and yellowish argillaceous limestone, composed largely of comminuted calcareous organisms. Fossils moderately abundant. *Amusium ocalanum* Dall, *Orbitoides*, and several species of echinoids, &c. . . . .

Section three-quarters of a mile below Blue Spring, west side of Flint River.

(Thickness not measured but estimated.)

Recent.
4. Sandy soil and humus . . . . 1 ft. to 18 inches

Pleistocene.
Feet.
3. Reddish sands and some gravel, thickness variable 6 to 10

Oligocene.
Chattahoochee formation.
2. Cherty limestone, in remnantal masses, not a connected stratum, containing many fossils, *Spondylus*, *Pecten*, *Turritella*, *Natica*, *Orbitoides*, *Orbicella*, *Calamophyllia*, *Astrocoenia pumpellyi*, &c.
1. Bluish, sometimes purplish clay. In this are large pockets of limonitic iron ore in masses often 10 to 20 feet long and 3 to 5 feet thick. Along the outer surface gravels are frequently cemented into conglomerate, but the gravel apparently was not originally a part of the stratum. Thickness 10

The clay surrounds the iron, being both above and below it and on its sides. No fossils were found in it. In one place the purplish clay contained carbonaceous particles.

Section at Hales Landing, about seven miles below Bainbridge on Flint River.

This locality is a wood landing on the west side of the river. About 100 yards above it is the first exposure. There are three rocky points along the Low Bluff. Feet.

Recent.
4. Soil and whitish sands containing a few pebbles and pieces or flakes of chert 4

Oligocene.
Chattahoochee formation.
3. Yellowish sand and masses of chert, the Chattahoochee formation, the chert residual in the sand 14

There is much gravel scattered over the surface of this layer, but apparently all of it could be derived from the chert of the quartz fillings of cavities of the rock. The residual character of the chert is plainly shown. It occurs as definite layers in places in the sand, passing by disintegration into them. Many of the cherty masses are large, weighing as much as several tons. The collection of fossils here was better than at Little Horse Shoe Bend, as many specimens were nicely weathered out. The fossils are silicified and in the case of the corals the internal cavities are frequently filled with crystalline quartz and some residual red clay. The corals include *Paracyathus*, *Trochocyathus*, *Stylophora*, *Astrocoenia*, *Orbicella*, *Dendracis*, *Astreopora*, *Poritidae*, and *Alveopora*, about 21 species. *Orbitoides* and echinoids are also present. Among the mollusks are *Conus*, *Fusus*, *Turritella*, *Natica*, *Cerithium*, *Terebra*, *Orthaulux*, *Pecten*, *Lucina*, *Venus*, *Venericardia*, etc. There is some clay with sand near the base of this stratum and there are indications of ferruginous pockets.

Vicksburg formation.
2. Blue clay, occasionally seen along water's edge . . . .

Vicksburg formation.
1. Orbitoidal limestone of the Vicksburg formation . . . .

This limestone is yellowish, brownish, or whitish, cherty in its upper portion. The fossils are very large *Orbitoides*, *O. papyracea Boubée* is very abundant, *Ostrea* (apparently *vicksburgensis*, *Pecten*, etc. Its mode of occurrence is extremely perplexing, as masses of it are at higher levels than No. 2 and parts of No. 3. At one exposure it rises 15 feet above the level of the river, and seems to exist as a solid ledge beneath the water's surface.

The apparent explanation is that there was a hill of the Vicksburg formation and because of subsequent erosion masses of limestone have rolled down and assumed the present position with reference to the other strata.

Chert of the Chattahoochee formation is exposed between the landing and the Bainbridge-Hutcheson Ferry road, and along the last-named road near the turn to go to the landing."

The following notes on the Chattahoochee formation are also supplied by Dr. Vaughan:

"*Powell Lime Sink.*—This is on the northern slope of a hill about eight and one-half miles east of Bainbridge, about three and one-half miles northwest of Climax, on Wm. Powell's land. The position of the sink is indicated by a patch of oak and other hard wood trees. Its perimeter is circular, about 200 feet in diameter. The depression is funnel-shaped with steeply inclined walls. At the bottom is a deep pit with almost perpendicular walls, with a cave leading westward from its bottom. The edge of the sink is some 20 feet below the top of the hill; from the edge of the sink to the edge of the pit is between 50 and 60 feet; the pit is about 25 feet deep. The entrance to this cave is through a steeply descending passage. The bottom of the sink is composed of soft, white, chalky, fossiliferous limestone. A fair number of very poor fossils were collected within the pit. They were *Natica*, *Pecten*,

Venus, &c., the greater number unidentifiable. The fauna appears to belong to that of the Chattahoochee formation, and the rock lithologically is similar to the Chattahoochee. There are at least 35 feet of limestone. Above the limestone in tne sink is 25 feet of stiff blue clay. The surface is composed of residual sand and clay. On the western side of the hill, along the road, at the same level as the upper edge of the pit, chert containing Chattahoochee fossils were observed.

Section down from hill at top of Powell lime sink.

	Feet.
Age ?	
5. Yellow sands	
Alum Bluff formation.	
4. Red clay, siliceous nodules in streaks, blue mottled clay below	40
3. Blue clays covered by residual clays and sands with siliceous and cherty streaks	20
2. Residual clays and sands	15
Chattahoochee formation.	
1. Fossiliferous chert	

Faceville.—Sanborn Mill Creek, a small stream flowing northwest from Faceville to Flint River, has exposed about 100 feet of strata of the Chattahoochee formation. The difference in elevation between Faceville and the level of Flint River is about 200 feet, and the distance is three miles. The stream flows down the steep westward-facing declivity of the Faceville plateau and has cut a narrow gorge revealing the underlying strata. Four Tertiary formations were recognized in the complete section. The top of the plateau is covered with a thin veneer of gray and brown sand. Beneath this are 40 or 50 feet of red sands belonging to the Altamaha (Lafayette?) formation. At the base of these sands, springs emerge which are in part the source of the creek. The next lower 50 feet is largely concealed and the character of the strata is inferred from the nature of the soil and a few poor exposures; the beds probably consist of sandy, laminated clays, becoming, towards the base, calcareous or argillaceous limestones; they occupy the stratigraphic position of the Alum Bluff formation. The Chattahoochee formation is mainly limestone, varying from hard, pure, crystalline limestone to very sandy and argillaceous limestone. In a few places are calcareous sands and bedded, calcareous clays. The upper part of the limestone contains a small percentage of phosphoric acid. There are present small Foraminifera, other invertebrate fossils and fragments of bones. The limestone is conglomeratic in appearance, but there is some doubt as to its being a true detrital conglomerate. Limestone beds in the lower part of the section have been quarried in a small way and are used locally for building stone. Fossils are nowhere abundant in the exposure. In the banks of Flint River, near the mouth of the creek, are large fragments of fossiliferous flint. This

rock contains large *Orbitoides* and other fossils, and is similar in its appearance to the flint of the Vicksburg formation at other localities. For the last half-mile of its course the creek flows through an alluvial plain bordering Flint River, and as there is no exposure of the older rocks the actual contact between the Chattahoochee and the Vicksburg could not be seen.

Recovery.—There are a number of sinks near the railroad one mile west of Recovery, in which brown, or gray, sandy, and argillaceous limestone of the Chattahoochee formation is exposed. This rock is similar to that exposed in the Faceville section. In places the limestone is silicified, being replaced by opaline or chalcedonic silica of vesicular appearance. Prof. McCallie[1] has noted large masses of silicified corals between Faceville and Recovery.

Wylie Landing.—This locality is on Flint River, five or six miles above its junction with the Chattahoochee, and one and one-half miles due north of the 254th mile-post on the Atlantic Coast Line railroad. The limestone exposed here evidently occupies the same stratigraphic position as the limestone at Faceville, and at the type locality, Chattahoochee, Fla.

Section at Wylie Landing. Flint River.

		Feet
3.	Bright red sand capping the bluff	?
2.	Massive-bedded limestone, weathered	40
1.	Greenish or bluish clay containing rock fragments . . .	10

The limestone is grayish or white, hard, and non-crystalline; some of it has a conglomeratic appearance similar to that at Faceville. The lower 10 feet is greenish, stiff, plastic, residual clay, in which are fragments of partially silicified limestone. This limestone contains corals, an oyster, and other fossils characteristic of the Chattahoochee formation. No trace of the Vicksburg formation was observed, and it is inferred that it has dipped beneath the river level above this point.

GRADY COUNTY

Whigham.—At Forest Falls, better known locally as Limesink, eight miles north of Whigham, nearly 100 feet of strata are exposed. This section and that at Faceville have been of great value in deciphering the stratigraphy of southwestern Georgia, and have been employed to a certain extent in field work as standards of comparison for poorer exposures at other localities. The lime-sink at this locality has a depth of 90 to 100 feet below the level of the surround-

[1]Geol. Survey of Georgia Bull. No. 5-A. p. 52.

ing land. Into it a small stream flows over a crest, approximately 70 feet above the bottom of the sink, producing a picturesque waterfall.

This locality was described by Prof. McCallie[1] in 1896, but the stratigraphic position of the beds was not discussed.

Section at Forest Falls.

	Feet.
Pliocene?	
Altamaha (Lafayette ?) formation.	
6. Red, yellow and gray sand, mottled near the surface. The sand contains brown iron oxide concretions, and greenish, "gummy" clay at the base	10 to 20
Oligocene.	
Alum Bluff formation.	
5. Greenish, plastic sandy clay, contains concretions of silica and fragments of bones	10
4. Yellow or buff calcareous and fossiliferous clay. The stratum is hard, and contains veinlets and minute geodes of calcite	5
Chattahoochee and Vicksburg formations ?	
(Crest of falls.)	
3. Calcareous clay grading into compact argillaceous, sandy limestone	27
2. Hard limestone having the conglomeratic appearance of some of the rock at Faceville and Wylie Landing	3
1. Very hard crystalline limestone, massive bedded. Parts of the bed are oölitic	35

Divisions 5 and 6 are exposed in a gully entering the sink from the north.

Section from the crest of the falls to head of the small creek flowing into the sink.

	Feet
Pliocene?	
Altamaha (Lafayette ?) formation.	
4. Red and yellow sand containing thin laminae of clay	10 to 20
(Unconformity.)	
Oligocene.	
Alum Bluff formation.	
3. Greenish or gray sandy clay	15 to 20
2. Soft, calcareous sandstone containing few fossils argillaceous compact sand containing nodules of calcareous sand	8
1. Indurated buff and greenish argillaceous sand veined with calcite and containing minute calcite crystals and geodes; base at crest of falls . .	5

Fossil swere collected by the writers and submitted to Dr. Vaughan, who placed the following interpretation upon the strata:

[1]Phosphates and marls of Georgia: Geol. Survey of Georgia, Bull. No. 5-A, p. 55.

Fossils from Forest Falls.

Fossils from the base of the first section given. *Orbitoides mantelli* Morton, *Pecten perplanus* Morton.
Horizon: Vicksburg

Fossils from 20 feet above base of the same section, *Orbitoides*.
Horizon: Chattahoochee?

Fossils from layer No. 2 in the second section given *Gonipora* sp. *Turritella*, and other gastropods, *Pecten sayanus* Dall.
Horizon: Alum Bluff.

No erosion unconformity was observed except the one separating the Alum Bluff formation from the overlying Altamaha (Lafayette ?) formation. The dense, crystalline limestone at the base of the sections seems to pass into the calcareous clay of the Alum Bluff formation without a perceptible break in the sedimentation. Fossiliferous flint such as characterized the base of the Chattahoochee in the vicinity of Bainbridge was not observed.

Bay Sink, three miles northwest of Forest Falls, is about 40 feet deep, and both limestone and flint are exposed near the bottom of the sink. The limestone is hard crystalline and closely resembles the basal rock at Forest Falls. The flint is evidently due to a silicification of this limestone. *Orbitoides Pecten,* and a coral were noted. According to Dr. Vaughan, the horizon here is in the Chattahoochee formation.

There are numerous other localities in the northern part of Grady County where limestones and flint of the Chattahoochee formation are exposed. At Little Limesink, three and one-half miles northeast of Forest Falls, 30 feet of limestone similar in lithologic appearance to the limestone at Forest Falls is overlain by greenish, sandy clays of the Alum Bluff formation.

Ocklockonee River.—A limestone, which probably belongs to the Chattahoochee formation, was found at Bishop Bluff, 13 miles southeast of Whigham, a short distance above the State line. The rock is poorly exposed and appears at only one point. It is a hard, buff-colored, argillaceous limestone veined with calcite, and having a similar lithologic appearance to some of the limestone phases at Faceville and Forest Falls. The rock outcrops in a bluff about 10 feet above the river.

THOMAS COUNTY

Original Pond and other localities.—Original Pond is located in the southern part of Thomas County, three miles west of Metcalf. The pond is due to a limesink and covers an area of about two acres. About 25 feet of limestone is exposed at the western end of the pond.

A. EXPOSURE OF LIMESTONE OF THE CHATTAHOOCHEE FORMATION AT STONY LAKE BLUFF, WITHLACOOCHEE RIVER, SEVEN MILES SOUTHEAST OF QUITMAN, BROOKS COUNTY.

B. EXPOSURE OF CHATTAHOOCHEE LIMESTONE IN BANK OF WITHLACOOCHEE RIVER, NEW BRIDGE (OR HORN BRIDGE) THREE MILES BELOW THE VALDOSTA SOUTHERN RAILROAD BRIDGE, LOWNDES COUNTY.

The lower 10 feet of the limestone is hard, brittle, brecciated, and vesicular, presenting a rough, jagged surface. The breccia consists of angular fragments of hard, dense, homogeneous limestone in a matrix of dull gray, porous limestone. There is a distinct difference between the color and texture of the angular fragments and the matrix, but both are comparatively pure calcium-carbonate. The breccia fragments are cream-colored or white, exceedingly fine-grained, homogenous, and break with a sharp, angular, conchoidal fracture; they have much the same texture as lithographic limestone. The probable explanation of the breccia is that as the rock consisted of alternate bands of dense, fine-grained limestone and more porous, earthy limestone, the sinking of the rock consequent from underground solution caused fracturing and resulted in the brecciated condition. There is no evidence that the fragments have been transported. Incipient silication of the fine-grained limestone has taken place and specimens representing moss agate in the process of formation were obtained.

The upper 15 feet of the exposure is dull-white, chalky limestone, less indurated than the lower rock. Foraminifera and other fossils are abundant. The slope of the hill above the limestone is strewn with fragments of phosphatic sandstone, probably weathered from the sandy clays of the Alum Bluff formation. The highest hills in this vicinity are 80 to 90 feet above the level of the pond.

The fossils observed were: numerous small *Orbitoides,* small gastropods, *Arca, Glycymeris, Pecten,* a small oyster, and corals. A large silicified coral, *Siderastrea,* not in place, was found. Dr. Vaughan identified from this locality: *Orbicella cavernosa* (Linn), and *Orthaulax pugnax* Heilprin.

Limestone similar to that at Original Pond occurs on the McIntyre plantation, five miles west of Metcalf, and 11½ miles south of Thomasville on the Thomasville-Tallahassee road. An exposure of 15 feet may be seen. This is hard, fine-grained, and brittle at the base, becoming soft and chalky at the top of the exposure. The soil above the limestone is red, sandy clay, strewn with fragments of siliceous concretions and fragments of phosphatic sandstones. Lying above the limestone there are about 40 feet of strata that belong to Alum Bluff formation. Greenish clay and brown sand, probably representing the base of the Alum Bluff formation were observed directly above the limestone in a gully along the public road. Specimens of *Ostrea mauricensis* occur in this clay.

Another exposure of the limestone of the Chattahoochee formation occurs at the old Copeland plantation, nine miles west of Metcalf, near the State line. Two or three feet of the rock is exposed at the

site of an old limekiln. It appears in every way similar to the limestone at McIntyre plantation and at Original Pond. The limestone occurs at the base of a hill, while on the slope above it there are fragments of flint and phosphatic sandstone.

Boston.—Limestone was observed at the abandoned phosphate pits three miles west of Boston, and at the Mitchell plantation six miles west of Boston. The character of the fossils, the lithologic appearance, geographic location, and stratigraphic relations, indicate that it probably belongs to the Chattahoochee formation.

At the old Toy phosphate pit three miles west of Boston, there are, at the base of the hill, poor exposures of limestone overlain by 30 or 40 feet of clay and sands, and some thin, interbedded, sandstone layers. The base of the hill is strewn with fragments of white flint, of hard, white to cream-colored limestone, and phosphatic nodules. The limestone has been largely silicified. A small *Orbitoides* (Chattahoochee species), a *Pecten,* and other fossils suggesting the Chattahoochee formation were observed. An oyster, which is probably *Ostrea mauricensis,* occurs in the overlying greenish, sandy clays. The overlying material is regarded as the equivalent of the Alum Bluff formation.

The limestone at this locality was studied in 1890 by Spencer[1] and was referred to "Middle Miocene.' The locality was subsequently visited by McCallie[2] and upon the basis of "numerous orbitolites" the rock was considered as probably the equivalent of the "White Limestone" of the upper Eocene (Vicksburg).

Limestone is exposed in a sink one-half mile north of the public road on the Mitchell plantation, six miles west of Boston. Only five or six feet of the limestone is exposed; it is a grayish or brownish compact limestone and in places has a conglomeratic appearance. It was formerly used in the manufacture of lime. Some of the partially burned limestone, when rubbed or struck with the hammer, gives off a pungent odor similar to that of hydrogen sulphide. On the whole the rock is similar to that exposed on the McIntyre plantation south of Thomasville. The fossils observed were *Orbitoides*, a *Pecten,* and poor specimens of gastropods and pelecypods. The overlying strata are not exposed.

There is a second sink about one-quarter of a mile south of the road but no natural exposures of limestone occur. There are a few large boulders of quartzitic, slightly phosphatic clay breccia or conglomerate. These probably belong to the Alum Bluff formation which directly overlies the limestone.

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[1]First Report of Progress: Geol. Survey of Georgia, 1890-1891, p. 82.
[2]Bull. Geol. Survey of Georgia No. 5-A, 1896, p. 60.

OTHER LOCALITIES.

Withlacoochee River.—What is probably the northern-most exposure of the Chattahoochee formation on this river appears at Stony Lake, five and one-half miles southeast of Quitman. Limestone is exposed for about one-half mile along the west bank of the river and rises four or five feet above low water.

Section of the Bluff at Stony Lake.

	Feet
Pleistocene.	
3. Gray and brown incoherent sand	20
Oligocene.	
Alum Bluff formation.	
2. Drab and white, semi-indurated fullers earth	14
Chattahoochee formation.	
1. Limestone and marl	4

The limestone is white or gray,—in places yellowish, argillaceous, very hard, non-crystalline, and in places bears numerous fossils. The bed of the river is strewn with fossiliferous chalcedony fragments that represent a silicification of the limestone. At one point along the bluff soft, marly clay and sand, one or two feet thick, containing *Pecten,* an echinoid, *Orbitoides,* and pieces of bones were observed. This soft layer seems to mark a transition from the limestone to the fullers earth. No evidence of an unconformity between the Alum Bluff and Chattahoochee formations was observed.

Impure, very sandy, and argillaceous limestones are found along Withlacoochee River above Stony Lake, but are regarded as phases of the Alum Bluff rather than of the Chattahoochee formation. Near Olympia, a short distance north of the Georgia-Florida State line, limestones typical of the Chattahoochee formation, appear in the bluffs and channels of the river.

Sections on Withlacoochee River at New Bridge three miles below the Valdosta-Southern Railway bridge.

	Feet
Pleistocene.	
4. Yellow, sandy clay	5
Oligocene.	
Chattahoochee formation.	
3. Layer of silicified coral, some specimens as much as a foot in diameter	1
2. Soft, white, or cream colored limestone	7
1. White, compact, pure limestone containing *Orbitoides* and other fossils	8

The limestone is prominent on both sides of the river and may be seen at considerable depths beneath water-level. From this locality

Orbitoides complanata, Cyphastrea, Orbicella cavernosa, and *Siderastrea,* have been identified by Dr. Vaughan. Near Olympia, a foot or two of white, compact limestone, apparently residual, may be seen at low water, overlain by a bluish sandy clay containing chalcedonic corals.

Allapaha River.—Limestone of the Chattahoochee formation was not observed above Statenville. A short distance below Statenville the limestone rises to 10 or 12 feet above the river. The Chattahoochee formation below Statenville consists of sandy and argillaceous compact limestone and some phosphatic conglomerate or phosphate pebbles in a calcareous matrix. It is overlain by unconsolidated, phosphatic sand and greenish, sandy clay. The formation is poorly fossiliferous, an echinoid being the only identifiable fossil except fragments of bones and sharks teeth.

Rock House, Crisp County.—This locality is five miles southeast of Cordele, and probably is an isolated occurrence of limestone of the Chattahoochee formation. The locality was called to our attention through a reference to it by Dr. R. M. Harper.[1]

The appearance of the limestone here is due to a sink as it is elsewhere concealed by the Alum Bluff and Altamaha formations. The section follows:

Section five miles southeast of Cordele.

	Feet
Pliocene?	
Altamaha (Lafayette ?) formation.	
5. A thickness of 30 or 40 feet, not well exposed; red sandy, and mottled clay containing a few quartz pebbles, appears in places	40
Oligocene.	
Alum Bluff formation ?	
4. Massive, weathered, greenish and drab clay	11
3. White, sandy clay, partly silicified and indurated	6
2. Grayish, very sandy clay	10
Chattahoochee formation.	
1. Massive, argillaceous limestone; contains *Orbitoides complanata*, the common Chattahoochee species, *Pecten*, and small gastropods. The clay and the limestone are not sharply separated	12

Ocmulgee River.—It is not improbable that the Chattahoochee formation is represented near Hawkinsville and Abbeville. In a bluff, one-half mile below Hawkinsville, Dr. Vaughan has identified *Alveopora* and *Amauropsis,* and suggests that the Chattahoochee formation is present. A coral was found in flint at Poor Robin Spring near Abbeville.

[1]Phytogeographical sketch of the Altamaha grit region of Georgia: Annals New York Acad. Sci., Nov. 1906, p. 17.

Millen, Jenkins County.—There is a small area underlain by limestone north of Millen. Natural exposures of the rock are rare, but its presence near the surface is indicated by the flat topography and occasional limesinks.

At Magnolia Spring, six miles north of Millen, a soft, yellow, marly limestone is exposed. An exposure, three feet thick, also occurs at a mill one mile south of the spring. The only fossils are bryozoans and a small, ribbed *Pecten* which has not been specificially identified.

On the Alexander Murphy place, nine miles northwest of Millen, limestone has been thrown from a well. The rock is white, fine-grained, sandy and rather hard. It contains a small *Pecten* and other poorly preserved fossils.

The age of the rocks exposed at the three preceding localities is in doubt. There are only a few exposures and the materials are poorly fossiliferous. Lithologically, the materials are unlike those of either the Claiborne group or Vicksburg formation, although from their geographic positions they might be referred to either of these. They are overlain by clays resembling those of the Altamaha and Alum Bluff formations. The rocks bear some lithologic resemblance to the limestones of the Chattahoochee formation, to which they are tentatively referred.

Jacksonboro, Screven County.—An exposure of limestone occurs on Briar Creek near the site of old Jacksonboro, about eight miles northeast of Sylvania, Screven County. This is one of the classic geologic localities of Georgia, yet only one natural exposure of the limestone has been found, and its distribution as a surface formation is insignificant. Sir Charles Lyell, who visited the locality in 1842, regarded the strata as of Eocene age. Dr. W. B. Clark[1] studied the fauna and expressed the opinion that it was probably Neocene in age. Dr. W. H. Dall[2] also discussed the age of the formation and expressed an opinion in favor of an early Miocene age. Dr. T. Wayland Vaughan in 1902 made a careful study of Lyell's locality, collected a number of fossils, and prepared a list of them which clearly showed their Oligocene age. Dr. Dall incorporated Dr. Vaughan's results in his "Tertiary fauna of Florida,"[3] stating:

> "The locality was again visited by Doctor Vaughan in 1902 and more material obtained, leaving no reasonable doubt that the Jacksonboro horizon is practically that of the Tampa limestone or *Orbitolites* bed of Florida."

The following are the fossils identified by Dr. Vaughan from the Jacksonboro locality:

[1]Bull. U. S. Geol. Survey No. 83, p. 55.
[2]Bull. U. S. Geol. Survey No. 84, p. 83.
[3]Trans. Wagner Free Inst. Sci., vol. 3, pt. 6, 1903, p. 1578.

Fossils from Jacksonboro, Screven County.

Orbitoides, small flattish species.
Actaeonina ? n. sp.
Bulla petrosa Conrad. Also Tampa.
Bulla 3 other species.
Pleurotoma servata Conrad. The variety found at Chipola.
Pleurotoma ? sp.
Drillia sp.
Olivella ? sp.
Marginella sp. Large species, 4 columella folds.
Mitra probably new.
Pyrazisinus cornutus Hpn ? Also Tampa.
Pyrazisinus 2 other species, probably new.
Cerithium georgianum Lyell and Sowerby.
Cerithium playtynema Dall. (Also Tampa.)
Cerithium n. sp. (Also Wakulla, Fla., Tampa horizon.)
Modulus turbinatus Heilprin. Also Tampa.
Acmaea n. sp.
Turritella tampae Dall var. (Also Tampa.)
Strombus albirupianas Dall.
Calyptraea aperta (Sol.)
Xenophora humilis Conrad.
Ampullina streptostoma Heilprin. Types from Tampa.
Amauropsis ocalana Dall. Also from Ocala limestone and Chipola.
Fissuridea sp.
Dentalium mississippiense Conrad.
Pecten sp. Apparently new.
Mytilus n. sp.
Chamalyelli. Dall.

ALUM BLUFF FORMATION

NAME

The name Alum Bluff is applied to all the strata lying between the top of the Chattahoochee formation and the base of the Miocene. These strata are the equivalent of the Alum Bluff formation of Florida, as recently defined, and as the formation is physically continuous from Florida into Georgia the use of the term is naturally extended to Georgia.

The formation was first studied on Apalachicola River at Alum Bluff, 25 miles below River Junction, Fla. The section at Alum Bluff was described in 1889 by D. W. Langdon[1] and the beds referred to the Miocene without differentiation. The name, Alum Bluff, used for a geologic division or formation, was first employed by Dr. W. H. Dall.[2] The succession at Alum Bluff as given by Dall[3] is as follows:

Section at Alum Bluff.

		Feet
6.	Yellow, unfossiliferous sand	70
5.	Lignitic sand	10
4.	Ecphora bed	30
3.	Alum Bluff beds	15
2.	Marl (Chipola)	5
1.	Chattahoochee limestone (?)	

The Alum Bluff formation, as described recently by Matson and

[1]Amer. Jour. Sci., 3d ser., vol. 38, p. 324.
[2]Bull. U. S. Geol. Survey No. 84, 1892, p. 122.
[3]Op cit., p. 113.

Clapp[1] includes more strata than was originally included by Dall, as the Chipola marl is considered a member of the Alum Bluff formation. As now used in Florida, the term embraces all the beds lying between the Chattahoochee formation and the Miocene.

The divisions of the upper Oligocene, Parachucla and Combahee, made by Sloan[2] on Savannah River, are the stratigraphic representatives of the Alum Bluff formation, and their use is not continued in the present report.

DEFINITION

Stratigraphic relations.—The Alum Bluff formation conformably overlies the Chattahoochee formation; the exact contact between the two is in places drawn arbitrarily, since there is neither an abrupt lithological nor faunal change from one to the other. There may be apparent unconformities due to solution and weathering of the Chattahoochee limestone near the contact. On Savannah and Altamaha rivers the Oligocene is separated from the overlying Miocene by an erosion unconformity, perhaps of minor importance. Throughout the greater part of the area underlain by the Alum Bluff formation the Miocene is absent, and the Alum Bluff is overlain unconformably by the Altamaha (Lafayette ?) formation, with which it may, in places, be confused on account of a similarity in appearance when weathered.

Lithologic characters.—The Alum Bluff formation presents a number of different lithologic phases; these include coarse, angular sand, coarse-grained, aluminous sandstone or grit, sandy clay, fullers earth, phosphatic sand, quartzites, sandstones, silicified clays, and local limestones or calcareous layers and nodules. Greenish or gray, argillaceous sands, and sandy, laminated clays, form the greater portion of the formation.

Beds of fullers earth occur in the formation both in Georgia and in Florida. The fullers earth is generally a gray or drab, faintly laminated, clay-like earth of low specific gravity. The earth is usually semi-hard and brittle, and in many places silicification has gone on to such an extent that the earth is very hard and rock-like, and no longer has the properties of fullers earth. Segregations of silica in the form of small, round, or flattened nodules is characteristic. The fullers earth beds do not attain any considerable thickness and are not persistent over large areas but appear to be local phases in sands and sandy clays. Greenish and drab, sticky, plastic clays, and argillaceous sands, are associated with the fullers earth beds.

[1]Second Ann. Rept. Geol. Survey of Florida, 1909, p. 91.
[2]Catalogue of Mineral Localities of South Carolina: Geol. Survey of South Carolina, ser. 4, Bull. No. 2, 1908, p. 273.

On Allapaha and Suwanee Rivers are phosphatic sands which are believed to lie directly above the Chattahoochee formation. Sands of the Alum Bluff formation on Savannah River are also slightly phosphatic. These sands are generally unconsolidated, or only slightly indurated, are sometimes coarse-grained, even containing small pebbles, and often display crossbedding. They consist largely of quartz; the phosphate is in the form of small, brown or black, slick, water-worn pieces of bones and teeth, varying in size from a pin-head to one-half or three-fourths of an inch in diameter. A small amount of clay is generally present and the sands, in a number of places, are calcareous and contain calcareous, phosphatic nodules. The chemical analysis[1] of a sample of sand from the Suwanee River, nine miles below Fargo, showed 16.80 per cent. of phosphoric acid (P_2O_5).

The clay and fullers earth phases of the formation have in places been silicified to such an extent that they have been converted into very hard claystones, and the argillaceous sands have become dense, virtreous, and brittle quartzites; clay breccias and conglomerates have likewise been silicified. In fact greater or less degrees of alteration of the rocks by silica carried in solution by circulating waters has been extensive. Opal and agate occur in places as a result of this silicification.

Samples of the silicified clays from Withlacoochee River, seven miles east of Quitman, were examined in the laboratory. They vary from bluish to light greenish and dove color, are hard, brittle, and break with a conchoidal fracture; the rock is dense and compact, and cracks are filled with opaline silica. Some of these rocks are slightly phosphatic. There are phases which might be termed opalized clay conglomerates or breccias; originally, this conglomeratic rock consisted of fragments of clay, either pebbles of clay or angular fragments, in a matrix of very sandy, lighter-colored clay or argillaceous sand, the matrix often containing oyster shells. By the infiltration of opaline silica, the rock has become dense, compact, and in places vitreous or glassy to such an extent that the sand grains are no longer recognizable. The clay is about 3 in the scale of hardness and it requires a strong blow with the hammer to break it. The lime of the oyster shells has been replaced by silica, and they are opalized and agatized.

In Grady, Brooks and Thomas counties thin beds of white sandstone, usually soft, were noted. These sandstones are associated with sandy clays and are often phosphatic, the phosphate forming, in part, the cementing agent.

[1]By Dr. Edgar Everhart, Chemist Geological Survey of Georgia.

Thickness.—The maximum thickness of the Alum Bluff formation in southwestern Georgia is estimated to be 150 feet. At no known locality can the full thickness of the formation be seen in a natural exposure; the estimate here given is based upon the record of a deep well at Valdosta. Samples from the depths of 150 and 176 feet in this well bore a close resemblance to the indurated fullers earth of the Alum Bluff formation, and limestone, probably of the Chattahoochee formation, was encountered at 186 feet. No natural exposures revealing a thickness of strata more than 40 or 50 feet were seen. Judging from the record of the Waycross well, it is probable that the Alum Bluff formation at this point is as much as 250 feet thick.[1] At Lumber City, in Telfair County, there is some probability that the Alum Bluff formation is as much as 200 or 300 feet thick. The natural exposures on Savannah Rived do not exceed 25 or 30 feet.

Paleontologic characters.—The formation is, on the whole, poorly fossiliferous. The clays and sands generally contain only poorly preserved casts and impressions. Doctor Vaughan obtained a number of species, listed on a subsequent page, in the vicinity of Bainbridge, and a well preserved oyster, *Ostrea mauricensis,* is found at a number of localities. The formation seems to mark the disappearance of the species of *Orbitoides* which are so common in the Vicksburg and Chattahoochee formation. On Savannah River the rare fossil,*Carolia floridana,* and *Pecten sayanus* have been found in this formation.

Areal Distribution.—The Alum Bluff formation underlies a large area in Georgia, extending from Decatur County northeastward to Savannah River; the northern limit of sedimentation during the Alum Bluff period is approximately marked by Cordele, Abbeville, Dublin, Millen, and Sylvania. No evidence of its occurrence north of these points has been found. Southward or southeastward from these points it is highly probable that the whole of the Coastal Plain is underlain by this formation. Througout most of this area, however, it has been covered by later sediments, and natural exposures are largely confined to bluffs of rivers.

It is the surface formation, and it influences the soil and topography over a large part of Decatur, Grady, Thomas, Brooks, Lowndes and Echols counties. Exposures appear in the bluffs of Ocmulgee and Altamaha rivers from near Abbeville to Doctortown. Alum Bluff strata may occur along Ogeechee River, but this has not been proven by paleontologic evidence. On Savannah River, the Alum

[1]Well record Underground waters of Georgia: Bull Geol. Survey of Georgia, No. 15, 1908, p. 172.

Bluff formation is believed to extend from near Hudson's Landing to Porter's Landing in Screven County.

Physiographic expression.—The area over which the Alum Bluff formation is the surface formation, is small, although a distinctive topography has been produced by its erosion and weathering in the southern part of the State. In the southeastern part of Decatur and the southern parts of Grady, Thomas, Brooks and Lowndes counties, the Alum Bluff formation, together with the Chattahoochee formation, has produced a topography more broken and hilly than that of the Altamaha region to the north. This topography is due, in part, to the argillaceous and sandy character of the Alum Bluff formation. The formation is easily eroded and the numerous lime sinks of the region have given an impetus to this erosion.

Structure.—The Alum Bluff formation has a very low southward and southeastward dip, certainly much less than the older Eocene and Vicksburg formations. On Savannah River, the dip does not exceed four or five feet per mile, and near the Florida line the beds must lie almost horizontally, since the streams have cut through them exposing the underlying formations. No evidence of broad flexures, or even minor folding and faulting was observed in the natural exposures of the strata. However, the probability of a broad arch existing in the southern part of the State has been mentioned in connection with the discussion of the drainage, and general structure of the Coastal Plain strata. (See pages 63-65.)

Economic geology.—The Alum Bluff formation contains beds of fullers earth which, locally, are sufficiently free from sand and siliceous concretions to be of commercial value. Fullers earth mining has been carried on at Attapulgus, Decatur County, for several years, and a good quality of earth for clarifying mineral oils is produced. The Attapulgus earth is very similar to that at Quincy, Fla. Brief descriptions of the deposit at Attapulgus have been published by Vaughan[1] and Veatch[2]. The prospects are favorable for finding commercial deposits in Decatur, Grady, Thomas and Brooks counties.

Sands containing a considerable percentage of phosphoric acid (P_2O_5) were observed along the lower courses of Suwanee and Alapaha rivers, and these may prove to be of some value in the future as low grade phosphates.

The clays, while on the whole poorly adapted for burned clay products, may be of some local value for common building brick.

[1]Vaughan, T. W., Bull. U. S. Geol. Surv. No. 213 1903, pp. 392-399.
[2]Veatch, Otto, Clay deposits of Georgia, Geol. Survey of Georgia. Bull. 18, 1909, pp.

LOCAL DETAILS

Baidbridge, Decatur County.—The following are notes by Dr. Vaughan on localities southeast of Bainbridge, at Roseland plantation, "Gastropod Gully" on the Bowers land, and on the Dickson farm, in Decatur County. Lists of fossils from the first two localities are furnished. "Gastropod Gully" was named by Dr. A. F. Foerste[1] who made a study of the beds and referred them to the Chipola of Florida.

"*Campbell Hill, Roseland plantation.*—The hill is composed of reddish and yellowish, residual sands. At the northeast corner of the hill, immediately west of a small ravine, a pile of yellowish, reddish, or whitish, siliceous sandstone, rich in fossils, was found. The fossils collected here belong to the same horizon as thoce in Judge Bowers' and Sam Dickson's fields. Some 20 or more species of mollusks were collected and listed as follows:

List of fossils from Campbell Hill Roseland Plantation.

Pleurotoma servata Conrad ?	Crucibulum auricula Gmelin
Pleurotoma	Natica alticallosa Dall.
Fulgur spiniger Conrad	Omphalius exoletus Conrad.
Melongena	Fissuridea sp.
Latirus?	Arca staminata Dall ?
Nassa	Arca sp.
Astyris ?	Spisula sp.
Astyris ?	Strigilla sp.
Bittium	Venus sp.
Serpulorbis ?	Carditamera sp.

Gastropod Gully, Bowers' Land. This gully is on Judge Bowers' land, east of Roseland plantation. It is 12 to 15 feet deep with almost perpendicular walls. The sides are composed of yellowish sands and of bluish clayey sands blotched with yellow. Bits of siliceous material are common and residual pieces of usually yellowish apparently silicified sandstones are abundant. Near the head of the gully it is shallower, and the residual sandstone is strewn promiscuously over the surface. Most of the fossils were found here. The gully is only about two hundred yards long.

Gastropod Gully is therefore, according to aneroid barometer readings, 85 feet above the level of Bainbridge at Hotel Wainman.

List of fossils from southeastern corner of Bowers' field, Foerste's Gastropod Gully locality.

Conus (probably planiceps Heilprin)	Crepidula
Pleurotoma	Crucibulum auricula Gml
Marginella	Natica alticallosa Dall.
Turbinella ?	Fissuridea
Fulgur spiniger Conrad	(2 undetermined gastropods).
Mazzalina ?	Arca staminata Dall.
Melongena	Arca santa rosana Dall.
Murex	Pecten chipolanus Dall.
Nassa (Chippola species)	Spondylus ?
Latirus ?	Carolia (probably floridana Dall).
Bittium	Mactra (Spisula) sp.
Turritella indenta var. mixta Dall.	Mactra ?
Turritella alcida Dall.	Strigilla (related to flexuosa Say).
Turritella 2 other species	Tellina (Angulus).
Solarium granulatum var. chipolanum Dall.	

[1]Amer. Jour. Sci., vol. 16, October 1893, pp. 245-254.

"*Sam Dickson's farm, six miles southeast of Bainbridge.* . In a field across a small. branch, on the south side of the road, are numerous boulders containing fossils. The material was originally a limestone but has been altered to a chert; it is yellowish in color, or occassionally reddish, and is similar to that found in the Bowers pasture. These boulders are residual masses left in yellowish or whitish sands. The fossils are poor casts or siliceous replacements and are the same as those found in the Bowers pasture. A small collection was made. The horizon is in the Alum Bluff formation."

Climax, Decatur County.—In the vicinity of Climax, are a number of exposures of gray, fine-grained, clayey sands, and greenish, plastic, sandy clays which are probably referable to the Alum Bluff formation.

A section of much stratigraphic interest is revealed in the cuts of the Atlantic Coast Line Railroad and an adjacent gully three-quarters of a mile west of Climax. The lower part of this section, from the level of the branch to the level of the track, consists of gray or greenish, laminated, sandy clays, and greenish or bluish clayey sands, considered referable to the Alum Bluff formation. They contain no fossils, and their stratigraphic position is inferred from their lithologic character, geographic position, and relation to the overlying formation. The section of this exposure given below has been furnished by Dr. Vaughan, and it will be further discussed in connection with the description of the Altahama (Lafayette ?) formation.

Exposure on north side of railroad, one mile west of Climax, from about twenty feet below to thirty feet above the level of the railroad.

	Feet	In.
Pliocene ?		
Altamaha formation.		
15. Soil and humus	5	
14. Yellow sand, some small gravel	5	
13. Mottled sands and clay	5	
12. Sands and some clay, showing stratification distinctly, whitish, yellowish, reddish, upper 20 feet crossbeded and ferruginous sandstane . . .	25	
Oligocene.		
Alum Bluff formation.		
11. Clays blotched reddish (abcut two feet below level of railroad)	5	
10. Stratified sands and clay, blotched red	6	
9. Stiff clay, blotched red	2	
8. Whitish sands with seams of clay	3	
7. Stiff blue clay, blotched red	1	
6. Finely laminated sand and clay	2	
5. Bluish clay resembling fullers earth, specimen collected, about	1	
4. Whitish sands	3	6
3. Clay similar to No. 1, some of which resembles fullers earth	2	6
2. Whitish sand, a little clay	6	9
1. Fine, sandy, bluish clay	1	6

"The lower portion of the section to No. 10, inclusive, was measured; the remainder was estimated and then checked by aneroid."

At Mashburn Hill, four miles north of Climax, approximately 60 feet of clays and sands are exposed which are here referred to the Alum Bluff formation. The bed consists of greenish, plastic, and very sandy clays, showing little stratification, in places thin interbedded layers of pure white sand. They are fine-grained, are free from pebbles, and contain white, irregularly-shaped, and flattened nodules of silica. They are overlain by yellow, argillaceous sand, containing black iron oxide concretions, evidently a product of weathering. The underlying clays and sands have been previously described by Veatch[1] as the Altamaha (Lafayette?) formation, but the detailed study of the Alum Bluff formation subsequently undertaken has lead to the belief that they are referable to the Alum Bluff formation. This conclusion is reached on the basis of lithologic character.

Attapulgus, Decatur County.—Attapulgus is located 13 miles south of Bainbridge, Decatur County. There are a number of exposures of sandy clays and fullers earth, which belong to the Alum Bluff formation. The fullers earth is of commercial value and is being mined. It has been described by Dr. Vaughan,[2] and the chemical and physical properties of both the clay and fullers earth have been described by Veatch.[3]

The pit of the Lester Clay Company, when visited in October, 1908, showed:

Section at pit of Lester Clay Company.

	Feet
Age ?	
4. Red, sandy clay covering slope	**?**
Alum Bluff formation.	
3. Stiff, tenacious, structureless clay apparently residual.	**6 to 10**
2. Fullers earth	**6 to 10**
1. Hard, greenish or drab, argillaceous sandstone . . .	**7**

The fullers earth presents very little structure; it is faintly laminated, the lines of stratification appearing only when the earth is dry. It is jointed and scales of manganese oxide often appear along the cracks. When moist, the earth is dull olive green in color, and slick or unctuous to the touch; when dry, it is white and brittle. It is distinguished from the greenish clays of the Alum Bluff formation by its low specific gravity, and high porosity; when dry it adheres strongly to the tongue.

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[1]Geol. Surv. of Ga., Bull. 18, p. 316.
[2]U. S. Geol. Surv., Bull. No. 213, p. 392.
[3]Geol. Surv. of Ga., Bull. No. 18, pp. 317-318.

The section revealed in the public road leading east from the station is:

Section in public road east of Attapulgus station.

	Feet
Age ?	
4. Red sand, in places argillaceous, capping the ridge	15
Alum Bluff formation.	
3. Plastic, greenish clay	4
2. Gray, very sandy clay	15
1. Bluish and greenish, stiff plastic clay	15

The red sand layer, No. 4, probably bolongs to the Altamaha (Lafayette?) formation.

In the railroad cut, one mile south of Attapulgus station, there is four feet of white or gray, very sandy claystone or sandstone, which contains poorly preserved fossils; this is overlain by a thin bed of shaly, brittle fullers earth and plastic clay, and probably represents the sandy bed observed in the bottom of the fullers earth pit.

Whigham and Cairo, Grady County.—The topography in the vicinity of these towns is broken and there are a number of exposures where the character of the Alum Bluff and its relations to the overlying Altamaha (Lafayette?) formation may be seen. The Alum Bluff formation consists mainly of greenish or gray, sandy, massive clays, thin beds of fullers earth, and gray and white phosphatic sandstones.

In a cut one mile east of Whigham, a bed of light greenish clay, somewhat in the nature of fullers earth, is overlain by orange-colored sands, and clays and sands alternately stratified. The clay bed shows some slight crumpling. It probably represents the Alum Bluff formation, while the overlying sands belong to the Altamaha (Lafayette?) formation.

The conformable relations of the Alum Bluff formation to the Chattahoochee limestone are revealed at Forest Falls, or Limesink, eight miles northwest of Whigham. The formation is mainly a sandy, compact clay and contains characteristic Alum Bluff fossils. This section has been described in detail on page 334.

In the cuts of the Atlantic Coast Line Railroad west of Cairo, the greenish, sandy clays of the Alum Bluff formation rise as high as 12 to 15 feet above the track and are unconformably overlain by the mottled sands and sandy clays of the Altamaha (Lafayette?) formation. On Tired Creek, three and a half miles west of Cairo, a cut reveals fossiliferous sandstone of the Alum Bluff formation.

Section on Tired Creek.

	Feet
Alum Bluff formation.	
4. Stiff, bluish or greenish clay, weathering brown	3
3. Very thinly laminated fullers earth	1
2. Soft, argillaceous, white sandstone, fossiliferous; contains *Ostrea, Carditamera tegra, Chione, Venus*	1
1. Pale-green, non-laminated clayey sand	5

A white sandstone, locally altered to quartzite, occurs on the Ragan plantation on Buck Creek, 10 miles south of Cairo. The sandstone is overlain by a "gummy," greenish clay with laminae of fullers earth. This sandstone is quarried for local building purposes.

Ocklockonee River.—The Alum Bluff formation is exposed along Ocklockonee River from the southern part of Colquitt County through Thomas and Grady counties to the Florida line. It consists of greenish or gray, compact sands, greenish clays, and gray, argillaceous sandstones. Poorly preserved fossils were found at some localities. It is often difficult to distinguish the formation, especially where weathered, from the overlying Altamaha (Lafayette?) formation. The contact between the two is revealed, however, east of Pine Park, in the cuts of the Atlantic Coast Line Railroad near the river, at mileposts 203 and 205. Near the Florida-Georgia line the river has cut through the clays, exposing limestones which probably belong to the Chattahoochee formation.

Thomasville and Boston, Thomas County.—In the hilly region south of Thomasville, and in the vicinity of Boston, the Alum Bluff formation is the main surface formation and, together with the Chattahoochee limestone, has determined the character of the topography, and to a considerable extent the character of the soil. It consists largely of gray and greenish clays, and compact, argillaceous sands, which upon weathering, produce red and brown sands and sandy clays. Layers of white, phosphatic sandstone occur which appear at the surface as brownish, both angular and rounded fragments strewn through the soil. Oyster shells are the common fossils, but associated with them are corals which were probably weathered from the underlying Chattahoochee formation. The weathered Alum Bluff materials might be easily confused with the Altamaha (Lafayette?) formation. At the few places where the Altamaha (Lafayette?) could be recognized it consisted of crossbedded, varicolored quartz sand and mottled, sandy clays. The Alum Bluff formation is distinguished by its greenish clays, usually containing fossils, and by its phosphatic sandstones.

The best exposures revealing the character of the Alum Bluff formation in this part of the State are at the old Toy phosphate pit, three and one-half miles west of Boston; a hill on the Mallet plantation on the Boston-Monticello road, four and one-half miles southwest of Boston; and at the McIntyre plantation, 11½ miles south of Thomasville. Sandy clays of the Alum Bluff formation overlie the Chattahoochee formation at these localities.

Greenish quartzite and quartzitic conglomerate, similar to that on Withlacoochee River, seven miles east of Quitman, appear on the Mitchell plantation, six and one-half miles east of Thomasville. This rock contains a small percentage of phosphoric acid. The underlying Chattahoochee formation also outcrops at this place.

Withlacoochee River.—The Alum Bluff presents a variety of phases along the course of Withlacoochee River and its relations to the Chattahoochee formation may be seen.

At Old Troupville, four and one-half miles northwest of Valdosta, about 15 feet of Alum Bluff strata is exposed in a bluff of Little River near its junction with the Withlacoochee; the rock here might be described as an argillaceous sandstone. There is a thin layer which contains poorly preserved fossils; *Turritella, Arca,* and agatized oysters were noted. In places, the rock has a brecciated or conglomeratic appearance, and is slightly calcareous and phosphatic.

At the Atlantic Coast Line Railroad bridge, seven miles east of Quitman, the channel of the stream is cut into a hard, greenish or bluish claystone. This rock is a semi-indurated or very hard rock, which was probably originally in the nature of fullers earth, but is now hardened by the infiltration of opaline silica which has formed the cementing substance of the rock. It contains knots or nodules more siliceous than the matrix, in some of which finely crystalline pyrite was observed. The rock does not show any distinct lamination or bedding.

The left bank of the river, one-half mile below the railroad bridge, exposes the following section:

Section left bank of river, one-half mile below Atlantic Coast Line Railroad bridge.

	Feet.
Pleistocene.	
4. Slope of incoherent, gray sand	15
Oligocene.	
Alum Bluff formation.	
3. Compact, clay breccia and quartzite	8
2. Fullers earth-like clay containng siliceous and calcareous nodules	15
Chattahoochee formation.	
1. Limestone, covered by water	?

A. EXPOSURE OF PARTIALLY INDURATED, PHOSPHATIC, CALCAREOUS SAND OF THE ALUM BLUFF FORMATION, ALLAPAHA RIVER, STATENVILLE, ECHOLS COUNTY.

B. LOWER SISTER BLUFF, ALTAMAHA RIVER, APPLING COUNTY, SHOWING STRATA OF THE ALUM BLUFF AND ALTAMAHA (LAFAYETTE?) FORMATIONS.

Beds 2 and 3 are referred to the Alum Bluff formation. No. 3 is in places a vitreous and brittle, amorphous silica, having imbedded in it pebbles and fragments of greenish clay; where unaltered it is a conglomerate of sand and green clay or fullers earth. The fullers earth is greenish and unctuous when moist, and drab and brittle when dry; it contains nodules of silica, often agate, and calcareous, earthy layers and nodules. No unconformity between layers Nos. 3 and 4 was noticed, although the conglomerate character of layer No. 4 suggests that the underlying clays were eroded during its deposition. The only fossils observed were oysters, which were imbedded in the silicified conglomerates.

The relation of the clays to the limestone of the Chattahoochee formation was observed in the bluff on the west side of the river two and one-half miles below the railroad bridge, near Stony Lake.

Section near Stony Lake.

	Feet
Pleistocene.	
3. Gray and brown sand covering the upper slope of the bluff	20
Oligocene.	
Alum Bluff formation ?	
2. Greenish and drab, semi-indurated fullers earth	14
Chattahoochee formation.	
1. Limestone	4

The fullers earth is brittle and crumbles when dry. It contains siliceous nodules. At one point a bed was observed which was thought to be a transition layer between the fullers earth and the limestone. It consisted of one or two feet of soft clay and sandy marl, containing numerous fragments of shells, *Pecten*, echinoids, *Orbitoides* and pieces of bones. No evidence of an unconformity between the limestone and the fullers earth was observed.

At Knight's Ferry, 11 miles southeast of Quitman, the Alum Bluff formation is a semi-indurated clay or fullers earth, partly silicified. The bed of the river at low water is strewn with fragments of chalcedony, agate, and white, rounded nodules or concretions of silica. About one mile above the wagon bridge there is a picturesque fall in the river caused by a bed of semi-indurated, sandy fullers earth protruding six or eight feet above the water and forming large boulders in the channel.

Allapaha River.—The nothernmost exposure of the Alum Bluff formation observed on Allapaha River is near Willacoochee, Coffee County, where two feet of stratified, fine, sandy clay appears in the left bank of the river, overlain unconformably by later sediments.

The following section appears in the east bank of the river at the bridge two miles east of Milltown:

Section two miles east of Milltown.

	Feet	In.
Pleistocene (terrace deposit)		
3. Brown or chocolate-colored, compact sand	5	
2. Pebbly sand, greenish quartzite, and white phosphate pebbles	1	6
(Unconformity)		
Oligocene.		
Alum Bluff formation.		
1. Greenish, sandy clay, containing siliceous and calcareous nodules	8	

Laminated, greenish or drab clays were thrown from a well near the old brick yard west of Stockton, and natural exposures of gray or greenish, sandy clays occur at Hotchkiss Mill, three and one-half miles northwest, and in the banks of the river at Milltown.

On the lower courses of Allapaha and Suwanee rivers in Georgia, the greenish, sandy clays, fullers earth, and quartzites seem to be represented by phosphatic sands. The sands are unconsolidated or only slightly compacted, in places are calcareous, and are made up principally of coarse, quartz sand and black and brown, water-worn particles of bones and teeth which vary from a pin-head to three-fourths of an inch in diameter. They contain only poorly preserved fossils, not sufficient to determine their age, but they directly overlie limestone which has the characteristics of the Chattahoochee formation. The only fossils which have been secured from these sands are a *Scutella,* from Statenville, and a *Pecten* related to *P. madisonius* from Suwanee River, 14 miles south of Fargo, together with poor prints of an oyster, and unidentifiable casts.

In the river bank and in a ravine a few rods below the wagon bridge at Statenville, Echols county, 14 feet of phosphatic sand is exposed. It is a coarse, gray, calcareous sand, full of brown and black, phosphatic particles. The sand becomes decidedly coarse, almost pebbly. Thin limestone layers occur in it, and it is strikingly crossbedded, the lines of stratification dipping 20 to 30 degrees from the horizontal. The phosphatic particles vary from the size of a pin-head to one-fourth or one-half inch in diameter.

Phosphatic and conglomeratic limestone of the Chattahoochee formation appears along the river below Statenville, in places rising as high as 10 or 12 feet above low water.

Exposures of phosphatic sands and greenish, laminated, sandy clays, similar to the material on the Allapaha, have been noted by Mr. S. W. McCallie[1] on the Allapacoochee near the State line.

[1]Geol. Surv. of Ga., Bull. No. 5-A. p. 82.

Suwanee River.—Suwanee River has its source in Okefenokee Swamp and flows through a low, flat, sandy plain. The river has formed no high bluffs, and exposures of strata other than surficial gray or white sands of Pleistocene age are rare and may be seen only at very low water.

Beneath the railroad bridge at Fargo is a greenish, sandy, fine-grained clay which appears about one foot above low water. It is overlain by brown, incoherent, quartz sand, a Pleistocene terrace deposit. The greenish clay probably belongs to the Alum Bluff formation, although it contains no fossils, and its age is inferred from its lithologic appearance.

At Bony Bluff, nine miles southwest of Fargo, three feet of gray, compact, calcareous sand probably belonging to the Alum Bluff formation appears at very low water. This sand is full of black, phosphatic pellets from the size of a flax-seed to one-fourth inch in diameter, and also contains large fragments of blackened bones, sharks' teeth and poorly preserved prints of shells. The phosphatic sand is overlain by eight to ten feet of brown and white sand of Pleistocene age. Large fragments of silicified wood not in place occur, but they probably came from the base of the Pleistocene sand.

Similar phosphatic sand was found at "The Rocks" or "Rocky Ford," five miles below Bony Bluff, and one-half mile above the Georgia-Florida State line. The bluff of the river at this point is 12 feet high at low water. The rock is in the bed of the river, but when the water is very low about one foot of it is exposed. It is a buff-colored sand, compacted by calcium carbonate; it is slightly more indurated than that at Bony Bluff and contains nodules of stone harder than the matrix, which appear to be due to segregations of calcium carbonate. Bones and prints of shells are abundant; two species of *Pectens,* an oyster, and a number of obscure casts occur. Dr. Vaughan has identified *Pecten madisonius* from this locality, and states that, although the formation here is provisionally classed as Oligocene, it may be Miocene.

The phosphatic sands on Suwanee River and on Allapaha River are similar in appearance, and probably occupy the same geological position, namely, directly above the Chattahoochee formation, and there may be a continuous sheet of these sands between the two rivers. The greater part of Echols, Clinch, and Charlton counties is a very level, sandy plain, and only Allapaha, Suwanee, and St. Marys rivers have cut through the Pleistocene surficial sand. The smaller streams have low, sandy banks, or flow through swamps, and since they have not cut through the sands, exposures of the older formations do not appear.

St. Marys River.—The occurrence of the Alum Bluff on St. Marys River is doubtful. If exposed at all, it is only along the upper 25 or 30 miles of its course after its issuance from Okefenokee Swamp. St. Marys River flows through a flat plain underlain by Pleistocene sand, and is generally bordered by low sand banks. The following section was observed at Smith Bluff, six miles north of MacClenny, Florida:

Section at Smith Bluff St. Marys River.

	Feet	In.
Pleistocene.		
6. White sand	2	6
Age ?		
5. Weathered clay and sand, red mottling	2	6
4. Clay	2	
3. Brownish, quartz sand	1	
2. Bluish, or drab clay	4	
Oligocene ?		
Alum Bluff formation (?)		
1. Bluish-gray sand, containing a small amount of disseminated clay, sufficient to make the sand compact, and minute phosphatic particles	15	

No fossils were observed either in the upper or lower part of the bluff. Lithologically the lowest stratum is not wholly unlike some of the Alum Bluff clayey sands observed at localities in Georgia. Beds 2, 3, 4, and 5 perhaps belong to the Altamaha (Lafayette?) formation.

Inasmuch as younger fossiliferous beds are found at Stokes Ferry, 11 miles south of St. George, it is not probable that the Oligocene extends further than the eastern angle of the river, in southern Charlton County.

Ocmulgee River.—Certain strata appearing in the bluffs from near Abbeville on Ocmulgee, to Doctortown on Altamaha River, are referred to the Alum Bluff formation. The age of these beds has been largely determined by their petrologic character and their stratigraphic relations to other formations. Conclusive paleontologic evidence of their age is wanting. They are underlain by lower Oligocene limestone and are overlain by beds of Pleistocene, Pliocene(?), and Miocene age. The presence of the Chattahoochee formation underlying these Alum Bluff beds has not been demonstrated, although there is a suggestion that the Chattahoochee formation exists near Hawkinsville and Abbeville where silicified corals have been found.

A number of sections of bluffs will be given to indicate the lithologic character and the relations of the Alum Bluff formation to other formations.

The following succession of beds appears at House Creek bluff, two miles east of Bowens Mill, Wilcox County:

Section at House Creek Bluff, Ocmulgee River.

	Feet	In.
Pleistocene (terrace deposit)		
Okefenokee formation.		
8. Thin covering of gray sand		
7. Mottled, red and yellow sand or loam	30	
Oligocene		
Alum Bluff formation.		
6. Greenish, fine textured clay containing sand pockets and siliceous nodules	10	
5. White, calcareous sandstone	5	
4. Bed of oyster shells in a calcareous, sandy matrix .	2	6
3. Greenish, clayey sand with calcareous concretions .	3	
2. Greenish, laminated, sandy clay	4	
1. Gray, compact sand	5	

The oyster-bearing beds of this locality are mentioned by Dall[1] as "presenting such a petrologic character as the Hawthorne beds of Florida." The Hawthorne beds are now regarded as approximately the age equivalent of the Chattahoochee.[2] Certainly the lithologic aspect of the beds at House Creek is more like that of the Alum Bluff formation of southwestern Georgia than of the Chattahoochee formation of the same region.

Section of Bluff at Lumber City, Telfair County.

	Feet
Pleistocene (terrace deposit)	
4. Thin covering of gray sand, level of second terrace . .	
3. Coarse, gray and red, pebbly sand; coarse pebble layer at base	15
(Unconformity.)	
Oligocene.	
Alum Bluff formation.	
2. Interstratified layers of greenish clay, and yellow and white, unconsolidated sand	10
1. Greenish and drab, sandy clay	15

No fossils were found here except in limestone fragments at the base of the Pleistocene.

In the bluff at Quinns "Fractions," four miles below Lumber City, similar sandy clays, together with a bed of vitreous quartzite, are exposed.

[1] U. S. Geol. Survey, Bull. No. 84, p. 81.
[2] Matson and Clapp, Fla. Geol. Surv. 2d Ann. Rept. 1909, p. 70.

Section at Quinns "Fractions," Ocmulgee River.

		Feet
Age ?		
5.	Upper slope of bluff, strata concealed	20 to 30
Alum Bluff formation.		
4.	Bed of quartzite, exposed	1
3.	Gray, compact sand containing clay laminae; contains poorly preserved prints of fossils	12
2.	Gray sand slightly indurated	3
1.	Greenish laminated clay with sand partings	5

At Oaky Bluff, two miles above the junction of Ocmulgee and Oconee rivers, thin slabs of greenish, brittle quartzite similar to that at Quinns "Fractions" appear. This is a low Pleistocene bluff and the quartzite extends only two feet above low water. Similar rock occurs on the Altamaha and probably lies in the channel of the river at Town Bluff, and also appears in the right bank of the river just above Nayles Ferry.

Oconee River.—Good exposure of beds, questionably referred to the Alum Bluff formation, occur at several bluffs on Oconee River. The materials are not typical of the Alum Bluff deposits, but differ from them only in being coarser and more irregularly-bedded; some of the coarser phases resemble the materials of the Altamaha (Lafayette?) formation.

Exposures have been examined at Berry Hill Bluff, Joyces Bluff, Stallings Bluff, and other bluffs between Dublin and the mouth of the river. Berry Hill is 55 miles above the mouth of the river and 10 miles west of Soperton.

Section at Berry Hill Bluff.

		Feet
Age ?		
3.	Loose gray sand and gravel on upper slope	
Alum Bluff formation.		
2.	Gray, alluminous sandstone, forms a precipice	50
1.	Sandstone and claystone, softer than the above	15

The sandstone is an indurated, coarse, feldspathic, quartz sand with disseminated greenish clay, the whole slightly cemented by silica. The rock varies from a claystone to a coarse sandstone almost a conglomerate. No fossils were found.

Joyces Bluff, two miles above Seaboard Air Line bridge.

		Feet.
Alum Bluff formation.		
9.	Mottled grit	10
8.	Gray, fine-grained, aluminous sandstone	5
7.	Drab claystone, containing coarse quartz grains	3
6.	Gray sandstone	4
5.	Hard clay	1

		Feet	In.
4.	Fine-grained sandstone	2	
3.	Greenish, massive, sandy clay	5	6
2.	Gray sandstone	1	6
1.	Drab, sandy clay	6	

Section of lower end of Joyce's Bluff.

	Feet
Age ?	
9. Upper slope, concealed	20
Alum Bluff formation.	
8. Fine-grained, gray sandstone	3
7. Coarse, feldspathic, conglomerate, crossbedded; pebbles an inch in diameter	7
6. Fine-grained sandstone	1
5. Massive, drab clay	4
4. Fine-grained, sandy clay, indurated and jointed	4
3. Yellowish sand	1
2. Feldspathic sandstone or grit	1
1. Greenish and gray, friable sandstone	8

Stallings Bluff, two miles west of Mount Vernon, is 45 feet high and is made up of rock similar to that at Berry Hill and Joyces Bluff. No fossils were found.

Altamaha River.—One of the best exposures of the Alum Bluff on Altamaha River is in the bluff at Grays Landing, 10 miles below the forks.

Section at Grays Landing.

	Feet
Age ?	
9. Incoherent gray sand, containing coarse gravel	2
Pliocene.	
Altamaha (Lafayette ?) formation.	
8. Mottled coarse sand and clay	8
7. Gray feldspathic sandstone or grit	20
Unconformity (?)	
Oligocene.	
Alum Bluff formation.	
6. Gray or greenish sand, compacted by disseminated clay	6
5. Greenish or gray sand, containing less clay than the overlying bed	5
4. Greenish or drab clay	2
3. Massive sand containing clay layers an inch or two thick	6
2. White, jointed, and laminated fullers earth	6
1. Compact sand and claystone	1

The fullers earth is very similar in appearance to the fullers earth of southwestern Georgia.

The Alum Bluff formation is represented at Upper Sister and Lower Sister bluffs, 48 and 49 miles, respectively, below the forks. The Alum Bluff strata exposed in the bluffs reach a thickness of

30 or 40 feet and consist of gray or greenish, aluminous sands and laminated, gray or greenish, sandy clays. The upper parts of the bluffs consist of coarse, feldspathic grit, the age of which is in some doubt. No fossils were found. These localities will be further discussed under the chapter on the Altamaha (Lafayette?) formation.

At Fort James, 58 miles below the forks, the lower part of the bluff, consists of fine-grained, aluminous, compact sand, gray or greenish in color, and is probably Oligocene. This material is overlain by coarse-grained, more feldspathic beds.

The Alum Bluff formation at Oglethorpe Bluff, eight and one-half miles above Doctortown, is exposed to a thickness of 15 feet and is unconformably overlain by unconsolidated sand and clay of the Altamaha (Lafayette?) formation. It consists of greenish clays, and gray or greenish, compact, aluminous sands.

The Alum Bluff formation, consisting of coarse, bluish or greenish, aluminous, compact sands, occurs at Linden, Bugs, and Doctortown bluffs, where it is unconformably overlain by Miocene strata. Sections at Bugs Bluff and at Doctortown will be described under the chapter on the Miocene.

The last high bluffs on the river are the Upper and Lower Sansavilla bluffs, 27 and 28½ miles, respectively, below Doctortown. There is a small thickness of coarse, crossbedded sand which may represent the Oligocene. The section at the lower bluff is:

Section at Lower Sansavilla Bluff.

	Feet
Pleistocene.	
3. Fine, brown and white sand	15
2. Sand containing thin layers of white or drab, laminated clay	20
Oligocene ?	
Alum Bluff formation (?)	
1. Coarse, crossbedded, bluish, aluminous sand	8

Ogeechee River.—The Alum Bluff formation occurs at two localities on Ogeechee River. A shaly, fullers earth-like clay and a greenish or gray siliceous claystone are exposed on the west side of the river, about one mile west of Rocky Ford. This rock rises about 20 feet above the water. No fossils were observed.

At Indian Head, three miles west of Egypt, Effingham County, two and one-half feet of sandstone, containing pockets of greenish, silicified clay, occurs in a slough on the property of Carl Higgins.

The rock at these localities are referred to the Alum Bluff formation purely upon the basis of lithologic character and geographic position.

Savannah River.—The northernmost exposure of the Alum Bluff formation on Savannah River was noted at Hudsons Landing, Screven County, 68½ miles above Savannah. The following section is exposed at the base of the bluff near the boat landing:

Section at base of bluff near Hudsons Landing.

Alum Bluff formation.	Feet	In.
3. Pale green, thin, calcareous clay containing indistinct impressions of leaves	0	1 to 2
2. Hard, sandy claystone, poor prints of fossils	0	3
1. To water's edge, dark green, coarse sand, argillaceous and compact; poor prints of fossils	1	

About 300 yards above the landing a bed of compact sand and fine-grained clay containing prints of fossils appears in the bluff 25 feet above the river; it is probably referable to the Alum Bluff formation. The presence of beds of upper Oligocene age at this locality has not been proven by fossils. The beds here lie above the Chattahoochee and Vicksburg formations, which appear at the surface to the northward and the succession of beds is similar to that at Porters Landing where beds of upper Oligocene age have been recognized by fossils; the stratigraphic position of the lower beds at Hudsons Landing is, therefore, inferred to be that of the Alum Bluff formation.

The following is a section of a bluff one-half mile below Hudsons Landing:

Section of bluff one-half mile below Hudsons Landing.

	Feet
Pleistocene (?)	
7. Gray, surficial sand	2
Pliocene ?	
Altamaha (Lafayette ?) formation.	
6. Coarse sand containing a small amount of clay, mottled red and gray; thin line of quartz pebbles at base.	30
(Unconformity)	
Miocene.	
5. Brown, fine-grained sand	7
Miocene (?)	
(Unconformity)	
4. Yellow and gray, unconsolidated sand; thin line of flat and discoidal quartz pebbles at base	20
(Unconformity)	
Oligocene.	
Alum Bluff formation.	
3. Light greenish, sandy clay, faintly laminated	6
2. Greenish-gray or ash-colored, compact sand	11
1. Red and brown, compact sand	4

As no well preserved fossils were found the correlations indicated in the preceding section are tentative.

In a bluff one mile below Hudsons Landing, Alum Bluff strata rise 30 feet above the river. They consist of greenish, compact, argillaceous sands which are massive and not laminated. No fossils were observed in these sands. The formation is separated from the overlying strata by a thin bed of nodular, fossiliferous, Miocene limestone containing *Mytilus conradinus* d'Orbigny.

The Alum Bluff formation appears in the lower part of a bluff at Porters Landing, 62 miles above Savannah. Sloan[1] was first to recognize the stratigraphic importance of this section and has made a careful study of it. The Porters Landing exposures are described in detail on pages 371-373 of this report.

MIOCENE

In earlier geological literature on the Atlantic and Gulf Coastal Plain the term Miocene included beds which are now placed in the Oligocene. For example, the Chattahoochee and Alum Bluff formations were formerly described as Miocene. Under the Miocene were included all the beds between the Vicksburgian and the Pliocene or Pleistocene. The necessity of a division, however, was recognized, and Dr. W. H. Dall distinguished the "old or subtropical Miocene" and the "new or Chesapeake Miocene." The "old Miocene" is now referred to the Oligocene division of the Tertiary, a discrimination due largely to the studies of Doctor Dall.[2] The Miocene here described refers only to that portion formerly designated "new or Chesapeake," which includes the strata lying between the Alum Bluff formation, and the Pliocene or Pleistocene. A summary of correlations of Tertiary horizons, according to the new classification, has been given by Doctor Dall. The name Chesapeake was used by Dall as a general term to include all of the Miocene of the Atlantic and Gulf Coastal Plain.

Dr. Vaughan[3] has recently made a paleontologic study of the Miocene at Porters Landing, Savannah River, Effingham County, and has correlated the late Miocene here [="Edisto" phase of Sloan, of his section[4]] with the Duplin marl of North Carolina, and considers the older Miocene here [= Marks Head of Sloan] the approximate equivalent of the Calvert formation of Maryland.

[1] Bull. South Carolina Geol. Survey No. 2, ser. 4, p. 273.
[2] Eighteenth Ann. Rept.., U. S. Geol. Survey, 1896-1897, pp. 327-348, Proc. U. S. National Museum, vol. 19, No. 1110, 1896, pp. 303, 304.
[3] Science, n. s., vol. 31, No. 804, May 27, 1910, pp. 833, 834.
[4] According to Doctor Vaughan the "Edisto" of Sloan in the Porters Landing section is not his "Edisto" of the vicinity of Charleston, but is a much later horizon.

MARKS HEAD MARL

NAME

The Miocene at Porters Landing was differentiated by Sloan[1] into two phases, which he designated the "Edisto" and Marks Head phases, respectively, correlating the former with the phosphatized Miocene marl on Edisto River, S. C., and applying a new name to the latter. Later, Dr. Vaughan[1] has shown that the lower of Sloan's phases, the Marks Head, is approximately synchronous with the Calvert formation of Maryland, and that the upper or "Edisto phase" is contemporaneous with the Duplin marl of North Carolina. The latter is stratigraphically higher than the Edisto marl of South Carolina.

The name Marks Head is derived from Marks Head, a small ravine one mile northwest of Porters Landing, Savannah River, Screven County, Ga. The Marks Head marl, although corresponding approximately to the Calvert formation, is separated from it geographically by a wide interval, and the different name Marks Head is therefore appropriate.

DEFINITION

Stratigraphic Relations.—The Marks Head marl rests upon the Alum Bluff formation of the Oligocene. The exposures on Savannah River furnish evidence of an erosion unconformity, separating the former from the latter. However, both the physical and faunal evidence seems to show that the time interval represented by this unconformity was relatively short. The formation is overlain unconformably by the Duplin marl. Since the Marks Head marl is of early Miocene age and the Duplin marl of late Miocene age, the unconformity separating them is an important one.

Lithologic Characters and Thickness.—The beds of this formation consist of gray or brownish, compact, argillaceous sands, containing large, calcareous nodules, and, in places, of friable, phosphatic sands containing shells. The phosphatic sands are mainly quartz sand with a small amount of phosphate in the form of small, brown and black, smooth or water-worn particles of bones and teeth, disseminated clay, and calcium carbonate in the form of shells and calcareous nodules. (See detailed sections, pp. 371-373.) The maximum observed thickness of this formation is 45 feet, this thickness appearing in some of the sections in the vicinity of Porters Landing on Savannah River.

[1]Op. cit.

Areal Distribution and Structure.—This formation has been differentiated at and in the vicinity of Porters Landing, Savannah River, Effingham County, Ga. It is doubtless represented in the undifferentiated Miocene occurring in sections above Porters Landing at least as far as Hudsons Ferry, and in the sections between Porters Landing and Sisters Ferry. (See detailed sections, pp. 371-375.)

So far as can be determined from the natural exposures the beds lie almost horizontally, having only a very slight dip southward, probably not more than three or four feet to the mile.

The formation is almost entirely concealed by later sediments, outcrops occurring only in the bluffs of streams; for this reason the beds have had little or no influence either upon the topography or upon the character of the soil of the region underlain by them.

Paleontologic Characters.—The formation has yielded a relatively small fauna, the collections coming chiefly from localities in the vicinity of Porters Landing, Savannah River. The fossils have been studied by Dr. Vaughan, who furnishes the following annotated list:

Table of fossils from the Marks Heal Marl.

Localities' Marks Head, one mile west of north of Porter's Landing.—Earle Sloan and T. W. Vaughan, collectors.

One-half mile above Porter's Landing.—L. W. Stephenson, collector.

One-half mile above Porter's Landing,—T. W. Vaughan, collector.

Porter's Landing, between the *Carolia* bed below, and the *Ostrea mauricensis* ledge above.—T. W. Vaughan, collector.

Porter's Landing, *Ostrea mauricensis* ledge.—T. W. Vaughan, collector.

Sister's Ferry,—L. W. Stephenson, collector.

NAME	Stratigraphic Range and occurrence	Marks Head, E. S. & T. W. V.	1 mi. above Porters Landing, L. W. S.	1 mi. above Porters Landing, T. W. V.	Porters Landing between *Carolia* & *O. mauricensis*, beds, T. W. V.	Porters Landing, *O. mauricensis*, bed, T. W. V.	Sisters Ferry, L. W. S.
Turritella aequistriata Conrad	Jericho, N. J.			x			
Neverita duplicata var. percalosa Conrad	Miocene to recent			x			
Calliostoma aphelium Dall	Jones Wharf and Calvert Cliffs Md.			x			
Calliostoma sp.			x	x			
Yoldia leavis Say							
Arca limula Conrad	Miocene and Pliocene	x					
Ostrea mauricensis Gabb	Eocene, Oligocene, lower Miocene of Jericho, N. J.	x	x	x		x	
Pecten marylandicus Wagner.	Jones Wharf, Md., etc.	x	x	x	x		x
Carolia sp. (floridana Dall ?)		x		x			
Mytilus conradinus d'Orb.	Throughout the Miocene	x	x	x	x		
Astarte yo. (also in the upper horizon at Porters)				x			
Venericardia perplana var. abbreviata Conrad	Miocene of York River to Pliocene			x			
Phacoides trisulcatus Conrad.	Oligocene to Pliocene			x			
Phacoides crenulatus (Conrad).	Miocene of Jericho, N. J., to Duplin horizon, N. C.			x			
Phacoides sp.				x			
Cardium laqueatum Conrad.	Jones Wharf, Md. to Duplin horizon, N. C.			x			
Dosinia sp.				x			
Macrocallista sp.				x			
Strigilla flexuosa Say	Oligocene to Recent			x			
Strigilla carnaria (Linn)	Hitherto only Recent			x			
Donax n. sp.			x	x			
Mactra sp. (hinge of large sp.)				x			
Spisula n. sp.			x				
Corbula n. sp.				x			
Balanus			x	x	x		

"*Geologic Horizon.*—The presence of *Carolia* in this bed suggests Oligocene, but every other identifiable species may be Miocene, and only three others range downward into the Oligocene; nine species are not known below the Miocene; of these nine, six are confined to the Miocene. The horizon is, therefore, in the Miocene, while the presence of *Turritella æquistriata* Conrad, *Calliostoma aphelium* Dall, *Ostrea mauricensis* Gabb, and *Pecten marylandicus* Wagner, definitely points to a horizon low in the series."

Economic Geology.—From an economic viewpoint the formation contains little of interest. It contains some phosphatic marls which may prove to be of local value as fertilizers or as fillers for commercial fertilizers.

DUPLIN MARL

NAME.

The name Duplin is derived from Duplin County, N. C. It was proposed as a formation name by Dr. Dall in publications appearing from 1895 to 1903.[1 2 3]

DEFINITION

Stratigraphic Relations.—The Duplin marl rests unconformably upon the Marks Head marl, or, where the latter is absent, upon the Alum Bluff formation of the Oligocene. The former relations were observed in the various sections examined at and in the vicinity of Porters Landing, Savannah River (pp. 371-373), and the latter relations are believed to obtain in sections on Altamaha River, at the bluff at Doctortown, at Buzzards Roost Bluff, and at Bugs Bluff (pp. 376-377.)

The formation is overlain unconformably by deposits referred in this report in part tentatively to the Altamaha formation, and in part to the Pleistocene (terrace deposits).

Lithologic Characters and Thickness.—The formation as exposed on Savannah River is mainly a shell marl, consisting of shells in a matrix of coarse, phosphatic sand; but in places it consists of a fine, gray, or brown, quartz sand, which contains scarcely any fossils or calcareous matter. The formation probably does not reach a thickness of more than 10 or 12 feet.

The Duplin marl on Altamaha River consists of friable, sandy, and pebbly shell-marl, and bluish, compact, fine-grained, argillaceous

[1] Proc. Nat. Mus., vol. 18, 1895, pp. 31. 40, 46.
[2] Eighteenth Ann. Rept., U. S. Geol. Survey, pt. 2, 1898, p. 338.
[3] Trans. Wagner Free Inst. Sci., Philadelphia. vol. 3, pt. 6, 1903, pp. 1598-1603.

sand which is also fossiliferous. The formation overlies, unconformably, strata of probable Alum Bluff age and is, in turn, overlain by vari-colored sands and clays which probably belong to the Altamaha (Lafayette?) formation. The Duplin marl does not reach a thickness of over 12 or 15 feet in natural exposures.

Areal Distribution and Structure.—The formation has been differentiated in the sections at Porters Landing, and at Mount Pleasant Landing, one and one-half miles below Porters Landing on Savannah River (pp. 371-374). It is doubtless represented in undifferentiated Miocene beds recognized in bluffs above Porters Landing as far as Hudsons Ferry, and below Porters Landing perhaps as far as Purisburg, S. C., 23 miles above Savannah. It has also been differentiated at Doctortown, at Buzzards Roost Bluff, and at Bugs Bluff on Altamaha River. The formation probably underlies much of the area, beneath surficial formations, between the occurrences on Altamaha and on Savannah rivers.

The Duplin beds dip to the southward at a very low angle, the inclination probably not exceeding three or four feet to the mile.

Except as revealed in occasional stream bluffs the formation is probably concealed over the entire area of its occurrence by surficial deposits, and for this reason has had little or no part in determining the topographic features or the character of the soils of the region.

Paleontologic Characters.—This formation has yielded a fairly large number of species in Georgia, although compared with the collections from the type region in North Carolina the fauna is small. The collections were made chiefly at Porters Landing on Savannah River, but a few species have been identified from Doctortown and from Buzzards Roost Bluff on Altamaha River. Dr. Vaughan furnishes the following annotated list of species identified from the Porters Landing collections:

Table of fossils from upper horizon of the Miocene, Porters Landing, Georgia.

L. W. S.=L. W. Stephenson, collector. T. W. V.=T. W. Vaughn, collector. D.=Duplin, N. C.		5191 L. W. S.	5241 Upper end of Bluff T. W. V.	5242 Lower end of Bluff T. W. V.
Scala sp. a			x	
Scala sp. b			x	
Scala sp. c			x	
Scala sp. d			x	
Scala sp. e			x	
Scala sp. f			x	
Turritella variabilis Conrad	D		x	x
Turritella duplinensis Gardiner	D	x		
Omphalius exoletus (Conrad)	D	x	x	
Calliostoma mitchelli (Conrad)	D		x	
Calliostoma armillatum (T. & H.)	D		x	
Fissuridea sp. yo	D		x	
Cadulus thallus Conrad	D		x	x
Nucula proxima Say	D		x	x
Leda acuta Conrad	D		x	x
Glycymeris sp. yo			x	
Arca improcera Conrad	D	x		
Arca sp. fragment			x	
Ostrea disparilis Conrad	D	x	x	x
Ostrea sculpturata Conrad	D	x	x	
Pteria colymbus Bolten			x	
Pecten eboreus Conrad	D	x	x	x
Pecten jeffersonius Say		x	x	
Pecten jeffersonius var. septenarius Say	D			x
Pecten sp.		x	x	x
Pseudamusium sp.				x
Plicatula marginata Say	D	x	x	
Anomia simplex d'Orb	D	x	x	x
Placunanomia plicata T. & H.	D		x	
Astarte concentrica Conrad	D		x	x
Astarte distans var. floridana Dall			x	
Astarte undulata Say	D		x	
Crassinella dupliniana Dall	D		x	
Venericardia granulata Say	D	x	x	x
Venericardia tridentata Say	D		x	x
Venericardia perplano Conrad	D		x	
Phacoides anodonta (Say)	D		x	
Phacoides radians (Conrad)	D	x	x	
Phacoides cribarius (Say)	D	x	x	x
Phacoides multilineatus (T. & H.)		x	x	x
Chione athleta (Conrad)	D	x	x	x
Venus tridacnoides var. rileyi Conrad		x	x	x
Venus tridacnoides Lamarck	D	x		
Transennella caloosana Dall				x
Tellina (Angulus) umbra Dall	D		x	
Tellina ? sp.			x	
Strigilla sp. fragment			x	
Mulinia congesta (Conrad)	D	x	x	x
Corbula inequalis Say	D		x	x
Balanus, probably 2 species			x	x
Crab chela			x	
Lunulites			x	x
Other Bryozoa, 2 species			x	x
Echinoid spines			x	x
Septastrea			x	
Astrangia ?			x	
Boring sponge ?			x	

Total number of identified species, 34 (not counting varieties), 30 of which are also at Duplin. The four species which have not been found there are as follows:

Pteria colymbus Bolten, the previously known range of which was from the Caloosahatchee Pliocene to Recent, or younger than the Duplin horizon.

Astarte distans var. *floridana* Dall. Miocene of Jackson Bluff, Fla., approximately the Duplin horizon.

Phacoides multilineatus (T. & H.) Known range from the Miocene of Maysville, S. C., to Recent; from the Duplin horizon to Recent.

Transennella caloosana Dall. Known range from Miocene of Jackson Bluff, Fla., to Pleistocene, from approximately the Duplin horizon to Pleistocene.

The bed whence the fossils came is evidently the stratigraphic equivalent of the Duplin marl of North Carolina.

Economic Geology.—The formation gives but slight promise of yielding products of economic value. It contains some phosphatic marls which may prove of local value as fertilizers, or as fillers for commercial fertilizers. The terrane may be of importance as a water-bearing formation since it probably is the source of many of the flowing wells obtained in Glynn, McIntosh, and Camden counties.

UNDIFFERENTIATED MIOCENE

Excepting the exposures in the vicinity of Porters Landing, at Mount Pleasant Landing, and at Sisters Ferry, it has not been possible with the available data to differentiate the Marks Head and Duplin divisions of the Savannah River sections, though doubtless both formations are represented at least from Hudsons Ferry in Screven County to Sisters Ferry in Effingham County. Detailed information concerning these undifferentiated Miocene beds are given in the chapter on local details, pages 377-379.

Fossils of Miocene age have been recognized in dredgings from Brunswick River at Brunswick, Glynn County, Ga., but they had been mixed by the dredging processes with large numbers of shells younger than the Miocene. Limestone tentatively referred to the Miocene occurs on the Livingston plantation, 18 miles west of Brunswick in Glynn County, and a calcareous sand at Owens Ferry, Satilla River, eight miles west of Woodbine, Camden County.

It is believed that strata of Miocene age underlie much of the region adjacent to the Atlantic Coast beneath beds of younger age; and it is considered not improbable that such strata may reach a thickness of several hundred feet. However, confirmatory evidence is lacking.

LOCAL DETAILS

Because of the limited area of the exposures, and as the different subdivisions recognized can not be definitely identified except at a few of the better exposures, the local details of the Miocene will be treated together.

SAVANNAH RIVER

Strata of Miocene age appear in exposures on and near Savannah River at intervals from Hudsons Ferry, Ga., 68½ miles above Savannah, to Purisburg, S. C., 23 miles above Savannah. Sections of a number of bluffs in which Miocene strata occur, and which are considered stratigraphically important, are given below. Final decisions as to the divisions and the age of some of the beds exposed from Hudsons Landing southward have not yet been made, and the conclusions here presented are only tentative. Some sections of interest in connection with the Miocene are given in the chapter on the Alum Bluff formation.

Hudsons Ferry.—A section observed one-half mile below the landing, in which 37 feet of undifferentiated Miocene is recognized, is given in the chapter on the Alum Bluff formation, page 361. The section described below occurs three-quarters of a mile below the landing.

Section at Landing three-quarters of a mile below Hudsons Landing, Screven County.

	Feet.
Pleistocene.	
8. Loose, incoherent gray sand	2
Pliocene ?	
Altamaha formation ?	
7. Mottled gray and red, coarse, clayey sand	10
6. Interstratified, harsh sand, and fine-grained waxy clay	10
5. Brown, ocherous, coarse sand; well-rounded pebbles at base	5
(Unconformity.)	
Miocene.	
Duplin marl ?	
4. Compact, ash-colored, argillaceous sand	10
3. Drab, and brown or yellow, sandy clay containing fossils, *Pecten madisonius*, and other fossils poorly preserved	2
(Unconformity.)	
Miocene?	
2. Massive-bedded, gray and brown phosphatic sand	25
Oligocene ?	
Alum Bluff formation (?).	
1. Concealed by creep from upper part of bluff	20

Division No. 3 contains prints of *Pecten*, poorly preserved leaf impressions, sharks' teeth, and dental plates of fish; at the base a few

well-rounded quartz pebbles appear. From its lithologic appearance and position in the section No. 2 is believed to be the equivalent of division No. 4 of Sloan's Porters Landing section which is subsequently given. Paleontologic evidence to confirm this is lacking.

Similar sections were observed in other bluffs in this vicinity and the Miocene seems to be separated from both the overlying and underlying formations by unconformities, which are marked by lines of small quartz pebbles. These pebbles are generally flat, oval, and discoidal, and are probably of beach origin.

Marks Head.—The following is the section at Marks Head, the type locality of the Marks Head formation, adapted from that given by Sloan.[1]

Marks Head, on the western side of Savannah River, one mile northwest of Porters Landing, near head of Marks Head Run.

		Feet.
6.	Surface sands.	
5.	Thin broken line of hard yellow marl.	
4.	Yellow-brown clayey matrix inclosing soft fossil shells	
3.	Partly indurated sand mass inclosing some fossil molds (2and 3 aggregate 14 feet in thickness).	10
2.	Blue-green matrix inclosing many small rounded black particles, and soft shells (*Pecten, Mytilus, Mytiloconcha, Arca, Anomia*, etc., etc.).	4
1.	Hard, sandy, brown matrix inclosing many soft shells. Extends below valley line increasing in hardness with depth	1

For a list of the fossils from this locality, see page 365.

Porters Landing and Vicinity.—The best exposures of the Miocene occur in the bluffs at Porters Landing, 62 miles above Savannah, and the section is of much stratigraphic importance. It has been studied in detail by Mr. Earle Sloan,[2] State Geologist of South Carolina.

The following section is based upon his descriptions, but the classification of the beds is changed to accord with the conclusions of Dr. Vaughan from a careful study of the fossils.

Section at Porters Landing, 62 miles above Savannah.

		Feet.
Age ?		
8.	White, yellow, and red sands in stratified beds of both fine and coarse-grained material	64
7.	Thin broken line of vertebrate remains, and small pieces of phosphate rock	
Miocene.		
Duplin marl.		
6.	Ledge of compact, yellowish marl enclosing *Pecten eboreus, Ecphora quadricostata*, numerous Anomias, etc . .	5.9

[1] Bull. Geol. Survey of South Carolina, series IV, No. 2, p. 274.
[2] Bull. Geol. Survey of South Carolina, series IV, No. 2, p. 273.

Marks Head marl.
5. Dun-colored mass of leached marl and indurated sands enclosing many rounded concretions of carbonate of lime encasing variable amounts of sand. Some concretions more than two feet in diameter. The basal portion is a hard concretionary layer (about a half foot thick) formed along a highly irregular surface. Stratum (5) appears at same level as the Marks Head marl at its type locality, one mile northwest 27
4. White sands enclosing a large number of one species of *Pecten* and numerous shell fragments, *Pecten marylandicus* Wagner 1.7
3. Fine-grained, laminated shale with sand partings. The median portion appears in the form of silicified concretions. The base includes a line of rounded pebbles . 14

Oligocene.
Alum Bluff formation.
2. A much leached marl enclosing *Carolina floridana* Pectens, sharks teeth, rib of cetaceans, and a large number of small, discoidal, quartz pebbles 6
1. Above zero water level appears 0 to 8 feet of a laminated drab shale with arenaceous partings. Enclosing molds of the Lucinidae, and at Hudsons Ferry impressions of the dwarf palmetto . . . .

Sloan recognized two divisions, the "Edisto" and Marks Head. In a subsequent study, Vaughan[1] correlated the upper Miocene horizon with the Duplin of North Carolina.

The following sections near Porters Landing are by the authors of this report.

Section 100 yards below Porters Landing.

	Feet.
Pleistocene ?	
6. Loose, gray sand	5
Pliocene ?	
Altamaha (Lafayette ?) formation ?	
5. White, yellow, and red sand	25
Miocene.	
Duplin marl.	
4. Bed of shell marl; shells in a matrix of coarse, phosphatic sand. Small, well-rounded, quartz pebbles at the base, resting unconformably on No. 3, *Pecten eboreus*, *Pecten jeffersonius*, *Anomia simplex*, *Arca*, *Phacoides*, etc	5
Marks Head marl.	
3. Brown or gray, phosphatic sand with large calcareous nodules, as much as two feet in diameter or length . .	30
2. Drab, or dark greenish, sandy, faintly laminated clay (no unconformity observed between Nos. 2 and 3.) . .	10
1. Sandy, drab clay, partly silicified, and contains hard, round, siliceous concretions. Phosphate pebbles, but not so abundant as in No. 3. Contains *Pecten marylandicus*	8

[1]Science, n. s., vol. 31, No. 804, May 27. 1910, pp. 833, 834.

As the basal beds of the bluff were under water at the time of making the section, the Alum Bluff formation was not studied at this locality.

An exposure appears about three-quarters of a mile northwest of Porters Landing.

Section one-half to three-quarters of a mile northwest of Porters Landing.

	Feet
Age ?	
5. Upper beds concealed	?
Miocene.	
Marks Head marl.	
4. Brownish quartz sand containing at the base a mass of shells and phosphatic sand, *Ostrea mauricensis*	6
3. Compact, gray, argillaceous and calcareous sand, phosphatic	18
2. White and brown sand, shells in white, phosphatic sand very abundant about the middle of the bed; fossils, *Carolia floridana (?)*, *Mytilus conradinus*, *Pecten marylandicus*, *Anomia*, *Area*, etc.	15
1. Concealed by talus to the level of the swamp	6

For list of fossils from this locality see page 366.

Section about 200 yards above Porters Landing.

	Feet
Pliocene (?)	
Altamaha formation ?	
10. Coarse, variegated sand with line of small, quartz pebbles at base	25
Miocene.	
Duplin marl.	
9. Fine, brown sand	4
8. Friable marl; shells in a matrix of coarse gray, phosphatic sand. Contains large, ribbed *Pecten*, *Anomia Area*, etc. A few scattered pebbles at base	2
Marks Head marl.	
7. Brown and ash-colored, compact, argillaceous sand	} 30
6. Compact sand; large, calcareo-phosphatic nodules	} 30
5. Calcareous ledge containing *Ostrea mauricensis*, 20 feet above the river level	} 30
4. Poorly exposed, probably sand, (about 4 feet)	} 30
3. Friable marl, shells in a matrix of gray sand, *Ostrea mauricensis*, *Pecten marylandicus*	4
2. Brownish, compact, sandy laminated clay, partly silicified	7
1. Greenish, sandy clay	4

Mount Pleasant Landing.—At Mount Pleasant Landing, one and one-half miles below Porters Landing, the Duplin marl is 40 feet above the river, and consists of eight feet of friable, highly calcareous shell marl overlain by coarse, brown sand which reaches a thickness of 10 feet. The shell marl here in places approaches somewhat the lithologic character of coquina, or friable shells in a

sand matrix, and is similar to some of that observed at Doctortown on Altamaha River. Beneath this upper bed is brown, phosphatic sand, similar to that at Porters Landing.

Section at Mount Pleasant Landing, one and one-half miles below Porters Landing.

	Feet.
Age ?	
1. Sand, and white, tough, waxy, laminated clay with sand partings. Stratum poorly exposed	20
Miocene ?	
2. Coarse, brown sand	10
Miocene.	
Duplin marl.	
3. Friable marl and limestone, contains shells and casts of shells, *Pecten*, etc.	7
Marks Head marl.	
4. Brownish, phosphatic sand	25
5. Greenish, sandy clay, not well exposed	20

At the Seaboard Air Line Railway bridge, three miles north of Clyo, there is 30 feet of fine-grained, white and yellow, sugar-like sand, the basal portion of which contains fine, brown, phosphatic grains. While this stratum contains no fossils, its lithologic character and geologic position suggest that it is of Miocene age. The two Miocene divisions (Duplin and Marks Head) can not be distinguished. It is overlain unconformably by 15 feet of strata referred tentatively to the Altamaha (Lafayette?) formation; the latter formation appears to increase in thickness westward from the bluff.

Sisters Ferry.—At Sisters Ferry, Ga., 47 miles above Savannah, and two miles east of Clyo, there is a good exposure of Miocene strata. The beds consist of greenish or gray, very sandy, laminated clay in the lower part of the bluff, and of crossbedded, red and white sands in the upper part.

Section at Sisters Ferry, Savannah River, Effingham County.

	Feet.	In.
Pleistocene.		
11. Thin covering of gray sand at the top of the bluff.		
Pliocene ?		
Altmaha formation ?		
10. Mottled red and yellow sand with some thin clay layers	20	
Miocene ? (Undifferentiated.)		
9. Coarse, crossbedded, yellow, red, and white sand	20	
8. Poorly exposed	10	
7. Drab, laminated clay, contains hard, sandy, calcareous nodules, covered with a crust of fibrous calcite,	7	
6. Hard, silicified clay	0	8

	5. Drab clay	0	3
	4. Hard, silicified, clay	0	3
	3. Laminated, gray, very sandy clay	2	6
	2. Hard, silicified clay	2	
Miocene.			
Marks Head marl.			
	1. Very sandy clay, contains some black phosphatic particles	3	

The only fossil which could be identified here was a *Pecten marylandicus,* which occurs near the base of the bluff.

About one-half mile below the ferry the dark-colored clays of the Miocene appear 25 feet above the level of the river. Southward from Sisters Ferry the river flows through low Pleistocene plains, and the bluffs along the river do not exceed 30 or 40 feet in height; along this stretch of the river there are few localities where satisfactory studies of the geological formations can be made.

Frying Pan Landing.—At Frying Pan Landing, eight miles below Sisters Ferry, greenish, sandy clay, similar in appearance to that at Sisters Ferry, occurs in the lower eight feet of the bluff.

Section at Frying Pan Landing.

	Feet
4. Loose, gray sand	4
3. Red, clayey sand	10
2. Brown and white, unconsolidated, rather pure, quartz sand	8
1. Gray and greenish, sandy clay	8

There are no determinable fossils and the divisions are made on the basis of lithology and geologic position. No. 4 may be safely considered Pleistocene. No means are at hand for definitely determining the age of division No. 3, but it is probably Pleistocene. No. 2 is probably Miocene, since the sandy clay of No. 1 is very similar lithologically to the Miocene at Sisters Ferry and Porters Landing. A similar succession of beds continues to Purisburg, S. C.

Ebenezer Landing.—At Ebenezer Landing, 34 miles above Savannah, beds corresponding in position to the Frying Pan Landing beds, rise about 18 feet above the river. The lower beds here are tentatively referred to the Miocene. They consist of brownish or yellow, compact, sandy clays, which contain poor prints and casts of fossils, and white and brownish, fine quartz sand.

Purisburg.—At Purisburg, S. C., 23 miles above Savannah, there is a bluff about 10 feet high, which exposes Pleistocene and older formations.

Section at Purisburg, 23 miles above Savannah.

	Feet	In.
Pleistocene.		
6. Red, sandy clay, containing small pebbles, color due to weathering	1	
5. Drab or white, laminated clay	3	
4. Line of coarse, quartz pebbles	0	3
Miocene?		
3. Gray or pale green, argillaceous sand	3	6
2. Thin line of quartz pebbles	0	3
(Unconformity)		
1. Gray or pale green, argillaceous sand	3	

Below Purisburg only Pleistocene deposits are exposed.

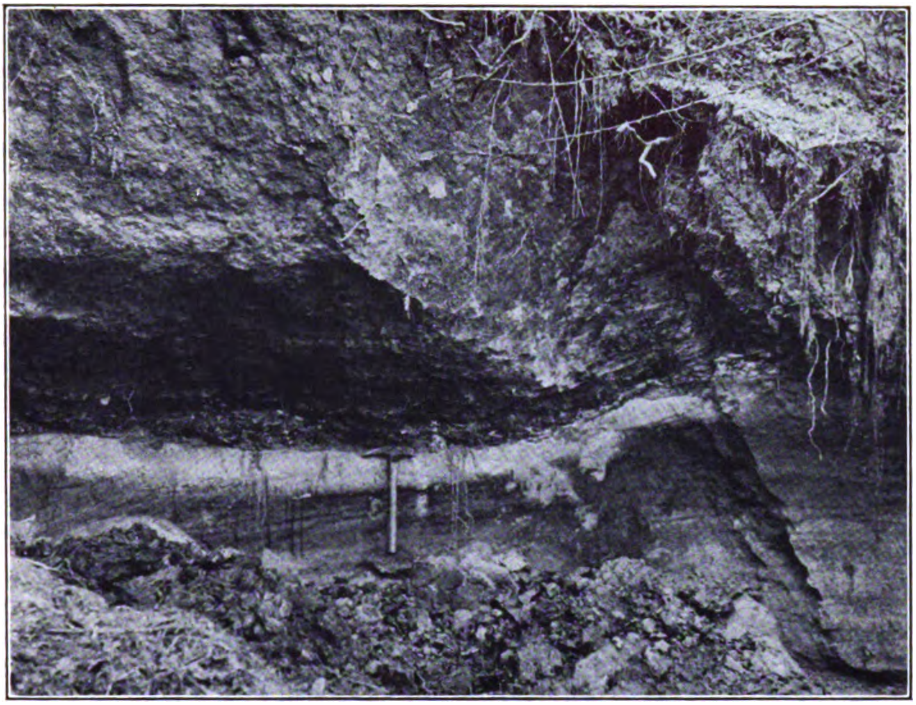
ALTAMAHA RIVER

Bugs Bluff and Buzzards Roost Bluff.—In descending Altamaha River the first exposure in which Miocene strata have been certainly recognized is at Bugs Bluff, two and one-half miles above Doctortown. Except that it yields no fossils the section is essentially like that at Buzzards Roost Bluff, two miles (by the river) above Doctortown. The Buzzards Roost exposure is described in detail as follows:

Section at Buzzards Roost Bluff, two miles above Doctortown.

	Feet	In.
7. Gray sand covering upper slope	2	
Pliocene ?		
Altamaha formation ?		
6. Mottled, clayey sand	10	
5. White, crossbedded, coarse sand, pebbly at the base	28	
(Probable unconformity)		
Miocene		
Duplin marl.		
4. Yellow and white, very sandy clay, pebbly in upper part, faintly laminated	5	
3. Blue, almost black, silty clay	6	
2. Shell and pebble conglomerate, contains *Pecten eboreus*, *Mytilus conradinus*	1	6
(Unconformity)		
Oligocene ?		
Alum Bluff formation ?		
1. Bluish gray, massive, compact, clayey sand	10	

Layer No. 2 is made up of well-rounded, quartz pebbles, coarse sand and shells. The whole is in places consolidated into a conglomerate, calcium carbonate forming the cement. Large fragments of water-worn, silicified wood also occur. The horizon is the same as that at Doctortown (Duplin horizon). The remainder of the section bears no fossils and the divisions are made upon the basis of physical differences and relations. The total thickness of the Miocene is 12 feet. It is separated from the underlying formations by an erosion



A. UNCONFORMITY, BETWEEN THE MARKS HEAD MARL AND THE DUPLIN MARL, JUST ABOVE ENOCHS WOOD LANDING, SCREVEN COUNTY, 67¾ MILES ABOVE SAVANNAH.

B. CHARLTON FORMATION. ST. MARYS RIVER. (FLORIDA SIDE) STOKES FERRY, 11 MILES SOUTH OF ST. GEORGE, CHARLTON COUNTY, GA.

unconformity, and probably also from the overlying formation by an unconformity.

Doctortown.—At Doctortown, Wayne County, the bluff of Altamaha River is 40 feet high, and near the base of the bluff beds of Duplin marl are exposed. The following is a section of the bluff at the south end of the Atlantic Coast Line Railroad bridge.

Section of Bluff at south end of Atlantic Coast Line Railroad Bridge.

	Feet
Pliocene ?	
Altamaha (Lafayette ?) formation ?	
6. Yellow and mottled, argillaceous sand	10
5. White and yellow, crossbedded sand containing thin layers of small, quartz pebbles	10
4. Red and yellow, stratified sand containing thin clay laminae	10
(Probable unconformity)	
Miocene.	
Duplin marl.	
3. Calcareous, fossiliferous sand, or sandy, friable marl	1
2. Bluish sand containing *Pecten eboreus*, *Mactra congesta*, etc.	4
(Probable unconformity)	
Oligocene ?	
Alum Bluff formation ?	
1. Coarse, bluish or greenish, compact, clayey sand to water's edge	7

The relations between layers Nos. 3 and 4 could not be determined with exactness. Layers Nos. 2 and 3 are Miocene. No. 5 is considered Oligocene, and the upper part of the bluff is referable either to the Pliocene (?) (Altamaha formation) or to the Pleistocene.

Below Doctortown there are no known exposures of Miocene strata, although beds at the bases of Upper and Lower Sansavilla Bluffs, 27 and 28½ miles, respectively, below Doctortown, may belong to this series.

GLYNN COUNTY

Brunswick.—At the southern limits of the city at the Atlanta, Birmingham, and Atlantic Railroad terminals, a large amount of shells and rocks have been dredged from Brunswick River. A study of the dredged material leads to the conclusion that the Miocene underlies this region and is concealed by a small thickness of later formations. The material thrown from the dredge consists of shells, fragments of bones and teeth, sand and quartz pebbles, compact, sandy marl or shells imbedded in a phosphatic sand matrix, argillaceous limestone, and hard clay.

A study of the fossils was made by Dr. Vaughan and they were found to range from Miocene to Recent. The dredge probably cut through a thin covering of Recent and Pleistocene deposits into the Miocene. Dr. Vaughan furnishes the following list of fossils collected from the dredgings:

List of fossils dredged from Brunswick River, Brunswick.

Septastrea crassa (Holmes).
Terebra dislocata Say.
Conus sp. Young.
Drillia abundans Conrad.
Oliva literata Say.
Olivella mutica Say.
Marginella contracta Conrad.
Fulgur carcia Linn.
Ecphora quadricostata Say.
Nassa vibex Say.
Ilyanassa obsoleta Say.
Nassa acuta Say.
Columbella avara Say var.
Astyris lunata Say.
Turritella variabilis Conrad.
Turritella plebeia Say?
Crepidula fornicata Say.
Neverita duplicata Say.
Solarium granulatum Lam.
Fissuridea carolinensis Conrad.
Dentalium carolinense Conrad.
Glycymeris parilis Conrad.
Glycymeris subovatus Conrad.
Barbatia adamsi Shuttlew.
Arca lienosa Say.
Arca plicatura Conrad.
Arca transversa Say.
Arca incongrua Say.
Arca limula Conrad.
Ostrea disparilis Conrad.
Ostrea virginica Gmelin, P. & R.
Pecten jeffersonius Say.
Pecten septenarius Say.
Pecten madisonius Say.
Pecten n. sp. ?
Astarte concentrica Conrad.
Astarte distans var. floridana Dall.
Astarte undulata Say var.
Astarte undulata var. vaginulata Say.
Astarte cuneiformis Conrad.
Crassatellites undulatus Say.
Crassatellites sp.
Cyralamera arata Conrad.
Venericardia granulata Say.
Echinocnama arcinella Linn.
Phacoides anodontus (Say).
Phacoides radians (Conrad).
Phacoides multineatus (Tuomey & Holmes).
Phacoides amiantus Dall, P. & R.
Diplodonta acclinis Conrad.
Cardium robustum Solander, R. & R.
Chione cancellata Linn.
Chione alveata Conrad.
Chione aff. cortinaria Rogers.
Donax.
Mulinia congesta Conrad.
Mulinia congesta var. contracta Conrad.
Mulinia congesta var. elongata Dall.
Rangia clathrodon Conrad.
Corbula inaequalis Say.

"*Geologic Horizons.*—At least two mixed, most of the species are Miocene, those marked P. and R. are Pliocene to Recent, and not known from the Miocene; all of the others may be Miocene, and many are only in the Miocene. The dredge has cut through what is probably Pleistocene or Recent into Miocene strata."

Livingston Plantation.—This locality is 18 miles west of Brunswick. The exposure is in the bed of a small creek and can be seen only at low tide.

Section at Livingston Plantation.

	Feet
Recent.	
3. Marsh mud	2

Pleistocene.
2. Greenish gray, argillaceous sand with some smoothly-rounded quartz pebbles. Bones and teeth in the lower part 3
(Unconformity)
Miocene.
1. Yellow, argillaceous limestone 2

A piece of coarse sandstone loosely cemented by lime, containing a *Pecten,* was obtained at this locality by Prof. McCallie.

The age of the beds has not been proven by paleontologic evidence. Layers Nos. 2 and 3 should probably be referred to the Pleistocene. Layer No. 1 is tentatively referred to the Miocene; however, this rock is similar lithologically to limestones of probable Pliocene age exposed at Burnt Fort on Satilla River, and near Folkston on St. Marys River, and future investigations may prove its Pliocene age.

CAMDEN COUNTY

Owens Ferry.—At this locality, eight miles west of Woodbine, a compact sand and calcareous sandstone is exposed in the bed of Satilla River at low tide. This rock contains fossils, but none are very well preserved. It is overlain by bluish, coarse-grained, clayey sand, while the upper part of the bluff is Pleistocene sand and clay. The following fossils from this locality have been identified by Dr. Vaughan:

Fossils from Owens Ferry.

Pecten, probably madisonius,
Carditamera arata,
Cardium sp.

PLIOCENE

The existence of strata of Pliocene age in Georgia has not been definitely proven. However, certain deposits have been referred with greater or less degrees of confidence to this period. The so-called Lafayette formation of the Atlantic and Gulf Coastal Plain has for many years been regarded as of probable Pliocene age. A summary of the events leading up to the adoption of the name has been given by McGee.[1] In a recent contribution E. W. Berry[2] has shown that the name Lafayette, as applied to a surficial formation in the Atlantic and Gulf Coastal Plain by McGee and others, is a misnomer, the beds exposed at the type locality in Lafayette County, Miss., being in fact of Eocene age and referable to the Wilcox formation of that series. However, a surficial formation consisting of

[1]Twelfth Ann. Rept., U. S. Geol. Survey, pt. 1, 1892, pp. 498-502.
[2]Journal of Geology, vol. 19, 1911, pp. 249-256.

sands and heavy beds of gravels resting unconformably upon Cretaceous and Eocene strata, to which the name was intended to apply, is extensively developed in certain parts of the northern embayment region, especially in Tennessee and Kentucky.

The so-called Lafayette formation is represented by McGee as covering the whole Coastal Plain of Georgia. Beds considered referable to this formation have been described at numerous localities in Georgia by different investigators, but on the following pages it will be shown that, assuming the formation to be of Pliocene age, many of these correlations were erroneous. Frequently the beds so referred have been found to belong to Cretaceous, Eocene, or Oligocene formations, or are the weathered, residual products of these formations. Terrace deposits which are clearly of Pleistocene age have also been referred to this formation.

The Altamaha (Lafayette?) formation, a widespread but relatively thin series of sands and clays covering much of central and southern Georgia, is tentatively referred to the Pliocene. Doubtless a part of the strata included in the Altamaha terrane is contemporaneous with the so-called Lafayette formation. However, the inadequacy of our knowledge of the age and stratigraphic relations of the Altamaha deposits is conceded. The possibility is also admitted that the beds here included in this formation may prove to be a complex embracing strata of all ages from the Oligocene to the Pleistocene.

Certain fossiliferous strata exposed on Satilla and St. Marys rivers have, on paleontologic evidence, been considered as probably of Pliocene age. The beds appearing on Satilla River will be described in the chapter on the Altamaha (Lafayette?) formation, since it is believed they are synchronous with at least a part of that formation. The exposures on St. Marys River will be described under the name Charlton formation.

On following pages the literature relating to Pliocene or supposed Pliocene deposits in Georgia is reviewed.

HISTORICAL REVIEW

In 1884 Dr. R. H. Loughridge[1] described beds which he considered of Pliocene age, as follows:

> The Savannah region along the coast, which occupies the first terrace at an elevation of from 10 to 15 feet above tide-water, is assigned to the Pliocene formation. Marls or shell beds of this age are found on the Savannah River near the Effingham and Chatham County lines. On Satilla River a white marl bed outcrops at Burnt Fort, the head of tidewater, which is

[1]Tenth Census, vol. 6, part II, 1884, p. 16.

mostly devoid of fossils. In the sand and clay beds of the coast region in Glynn, Chatham, and other counties have been dug up the remains of gigantic quadrupeds, such as the mastodon, and along its borders are buried stumps of cypress and other trees still standing upright.

Loughridge referred strata both older and younger than the Pliocene to this period. The "marl or shell beds" on Savannah River are in part of Miocene and perhaps in part of Oligocene age. (See pp. 370-376 of this report.) The sands and clays of the coast region which bear remains of quadrupeds and contain buried tree stumps are believed to be of Pleistocene age. No fossils have been identified from Burnt Fort, but the beds are regarded as the equivalent of the fossiliferous beds on St. Marys River (Charlton formation) which Dr. Vaughan regards as probably of Pliocene age.

In 1891 W J McGee[1] described the deposits in Georgia which he regarded as referable to the Lafayette formation. The following are quotations from his report with comments by the writers:

"The exposures on both sides of the Chattahoochee River at Columbus are specially noteworthy, not only by reason of the clear display of structural and textural features, but because the terracing which characterizes the formation at many localities is here particularly well displayed. Columbus is built on a terrace a mile broad, thinly veneered with "second bottom" (Columbia) loam near the river, but consisting generally of the orange-red loam of the Lafayette, massive above, mottled 8 to 15 feet below the surface, and more or less definitely bedded below; Phoenix, or Lively, on the opposite side of the river, is built on a higher terrace of bronze-tinted loam, here containing moderately abundant disseminated pebbles, and the many excellent exposures in the railway and street cuttings well display the stratification of its lower portion. . . * . . * . . (p. 478.)

"On examining the materials composing the formation at Columbus, certain new features apppear. As usual, the upper part of the deposit is orange tinted loam, massive, rock-like, undergoing superficial cementation on weathering, and flecked or streaked with white; but the color is lighter than in Mississippi, the proportion of sand is smaller, the sand grains are coarser and more angular, and the flecks and streaks of white are no longer of siliceous clay or pulverulent amorphous silica but of kaolinic clay or kaolin. The lower portion of the formation displays a bedding as distinct as the stratification of Mississippi, but the bedding is simply a separation of the loam into heavy, rock-like ledges parted by leaves of clay, sand, and gravel, quite unlike the inter-stratification (with occasional cross-lamination) of sands and clays in the western part of the terrace; so, too, the materials of the intercalated clay leaves are changed, instead of the siliceous pottery clays of Mississippi and Tennessee they are chiefly a kaolin-like material, with occasional quartz crystals and mica scales included; and the pebbles are no longer of chert, as in Mississippi and Tennessee, or even the mixture of cherts and siliceous dolomites found on Tuscaloosa River, but mainly of granular quartz with occasional well worn bits of quartzite. (p. 478.)

"The exposed thickness of the formation about Columbus is generally 10 to 30 feet; and the combined exposures indicate that while the thickness is exceedingly variable it probably reaches a maximum of 50 or 70 feet. * * * * (p. 478.)

[1]Twelfth Ann. Rept., U. S. Geol. Survey, pt. 1, 1891, pp. 478-480.

"Along the Chattahoochee River about Columbus, and southward nearly or quite to the confluence of the Flint, the Lafayette deposits are not concealed by the newer Columbia formation save along the rivers, which are all flanked by the "Second bottom" loams characteristic of the rivers of the eastern Gulf slope * * * (p. 479.)

"In the vicinity of Columbus, particularly on Mill Creek, between Phoenix and Girard, the Lafayette rests, either with or without marked unconformity, on the Potomac (Tuscaloosa) arkosic sand and clay; the materials of the terrace east of the river and north of Columbus generally lie on the eroded surface of the Piedmont gneiss; within 2 or 3 miles south of Columbus the Lafayette rests unconformably (though sometimes the unconformity is inconspicuous or even imperceptible) on the sands of the Eutaw; while still farther southward it reposes with like unconformity successively on the Ripley, the various divisions of the argillaceous Eocene (Hilgard's Lignitic), the White limestone of Smith and Johnson, and Miocene limestones. About Columbus the materials of the basal part of the Columbia, of the Lafayette, of the Potomac (Tuscaloosa), and sometimes of the Eutaw, contains certain common elements and sometimes approximate in composition so closely that they may be discriminated only by structural characteristics; and in some of the most conspicuous exposures near the mouth of the Mill Creek the Lafayette and the Potomac (Tuscaloosa) have not been certainly discriminated." (pp. 479-480.)

The deposits on the plains bordering Chattahoochee River in the vicinity of Columbus, and extending down the valley from Columbus, are Pleistocene terrace sediments which rest upon Cretaceous, Eocene, and Oligocene strata.

"The lower portion of Macon is built on a "second bottom" plain, but the residence part of the city stands on the amphitheater-like slopes semicircling the terrace occupied by the low-lying business portion; and in every street and country roadway, in every excavation on railways entering the city from the west, northwest, and even from the southeast, the orange-tinted loams are well displayed, always with the prevailing color and frequently with characteristic structure; so the roads, streets, railways, and hill slopes of the most of Macon gleam red against the dark green background of the pine-clad hills. Here as elsewhere the material is a loam, containing a sufficient element of clay to produce considerable coherence, orange red or or sometimes brick-red above, mottled orange yellow at greater depths. Here, as elsewhere, the formation is characterized by irregular stratification and rather obscure crossbedding in its lower portion, the structure lines being marked sometimes by ferruginous crusts and sometimes by lines of pebbles or gravel grains, but more frequently by sheets of white plastic clay, sometimes continuous, sometimes in layers of distinct pellets. Here, as elsewhere, the upper part of the deposit is massive, and diplays in an eminently satisfactory manner the distinctive semiglazing or case-hardening by which the formation is generally characterized. Here, as elsewhere, the deposit is frequently pebbly, the pebbles being either arranged in lines of stratification or accumulated in pockets and in beds, sometimes assorted by size, and as usual the pebbles are commonly disseminated above and commonly bedded below; and here, as at Columbus, the pebbles consist predominantly of mederately well rounded and subangular fragments of quartzite and quartz, ranging from 3 inches in diameter downward, and there are in addition a few granitoid fragments. (p. 480.)

"The relations of the Lafayette formation to the Columbia "second bottom" are not well displayed, but the relations to the Potomac are admirably displayed in many exposures. The eminence in the western part of the city known as Primrose Hill is a cusp of Potomac arkose only veneered with

the Lafayette, and the street cuttings and gullies by which it is laid open along many lines display the two formations in contact, sometimes conformable in structure and concordant in materials to such an extent that they may not be demarked, but elsewhere strongly unconformable in structure and discordant in composition. Precisely similar relations are displayed in the half dozen or more excellent exposures on the Georgia Southern Railway in the western part of the city, in some of which the formations are quite distinct, while in others they intergrade." (pp. 480-481.)

The physiographic features at Macon are: (1) terrace or "swamp" 15 to 20 feet above the level of Ocmulgee River; (2) terrace plain 40 to 50 feet above the first plain; (3) upland plain 100 to 125 feet above the second terrace plain. McGee does not describe this terracing in detail, but it is inferred that he considered the Lafayette as occurring on all three plains. Both the second terrace and the higher land have gravel and red loam deposits spread over them, but these deposits are evidently of different ages since they are separated by a vertical interval of as much as 100 feet, and the deposits do not appear to form a continuous mantle over the escarpment between the two plains. Those on the lower two plains are Pleistocene terrace deposits. The red loam deposits on the high land west and south of Macon are lithologically similar to the Eocene strata capping the hills on the east side of Ocmulgee River, and it is believed that they correspond to them.

"Over the divide between the Ocmulgee and the Oconee the Lafayette appears in many exposures." (p. 481.) No localities where the exposures appear are mentioned. There are in places deposits of red sand unconformably overlying the Cretaceous which might be mistaken for surficial deposits but which have been shown by their contained fossils to be of Eocene age. At other places there are similar sands which do not contain fossils, but these can usually be traced into fossil-bearing Eocene beds. It is believed, therefore, that McGee has mistaken the red Eocene sands for the Lafaytte formation.

The formation is mentioned as occurring in the vicinity of Millen (p. 481), but no particular locality is described. In this report these deposits are considered referable to the Altamaha formation.

"* * * But on returning to the fall line the normal fall-line features recur, as in the fine exposure near Green's Cut (10 miles south of Augusta) where the usual aspect of the massive loam is well displayed. At this point the deposit is exceptionally pebbly, to the extent, indeed, that it has been largely worked as gravel for railway ballast, the pebbles ranging from 2 inches down, the most abundant dimensions being three-fourths to one and one-quarter inches; the materials are predominantly quartz and quartzite, with no chert, the prevailing form being fairly well rounded, and the pebbles are accumulated in layers, sometimes discontinuous, in which it is occasionally cross-bedded, though even in these layers the gravel is nowhere clean, the pebbles being simply disseminated closely throughout a

matrix of loam just as the finer sand grains are disseminated through a clay matrix in the loamy parts of the formation." (p. 481.)

At Greens Cut on the Central of Georgia Railway, 27 miles south of Augusta (probably the locality referred to in the above description), is a deposit of mottled sands and gravels overlying the Barnwell sand of the Claiborne group. These have much the aspect of the Altamaha formation which appears to the southward and they are believed to be referable to it.

"In central Georgia the Lafayette forms the surface on the Ocmulgee and the Oconee rivers, save where the "second bottoms" overlap it; but farther eastward, on the Ogechee as well as toward Savannah, the distinctive "second bottoms" proper disappear, and the coast-sand mantle stretching up from the seashore, and along the Savannah finally overlaps the Lafayette and extends upon the Piedmont gneiss, from which the orange-tinted formation has been removed, if it was ever deposited." (p. 481.)

Just what is meant by "second bottoms" is not clear, but here, as elsewhere in Georgia, the materials occupying definite plains bordering the rivers are considered Pleistocene terrace deposits.

"In southwestern Georgia, e. g., about Thomasville, the characteristic orange tinted or brick-red loams (in this direction the colors strengthen) are not concealed by the coastal sands of the Columbia epoch, except about the lower levels; but in southeastern Georgia there is a more or less continuous mantle of these sands, by which the Lafayette is commonly buried from sight. In passing southward from Thomasville the features of this formation and its relations to the Columbia are well displayed." (p. 482.)

The so-called Lafayette materials referred to in the preceding quotation are in this report considered referable to the Altamaha formation; they overlie the Alum Bluff formation (Oligocene).

"The Lafayette is well exposed on the southern bank of St. Mary's River, near Traders Hill. Here the upper part is orange brown or drab and massive for a few feet, but it quickly becomes regularly bedded, the heavier layers of brown or gray clayey loam separated by leaves of gray silt and brown or drab sand. It is again displayed in many railway cuttings about Waycross, where the upper massive member is better developed yet decidedly less distinctly massive, orange-tinted, and casehardened than in central Georgia, while the lower part is always stratified. It is revealed to a depth of 40 feet or more at Doctortown in a railway cutting through a natural bluff overlooking the Altamaha; here the upper member is ill developed or absent and the mass is stratified throughout, consisting of alternations of brown loam and white silt above and in the lower part of the exposure these become, respectively, blue or gray clay and light colored sand. Still farther northward the formation approaches within 10 miles of the sea islands and inlets in the Cherokee Ridge on the southern side of the Savannah. The upper massive member is fairly displayed here, though orange yellow rather than of the characteristic color, while the lower portion consists of stratified sand with fine gravel disposed in sheets." (p. 484.)

A detailed section at the Atlantic Coast Line bridge near Folkston, probably the Traders Hill locality, is given on page 398 of

this report, and the stratigraphic relations of the beds discussed. The strata above the Charlton formation (probably Pliocene) are considered of probable Pleistocene age. The materials exposed near Waycross are, in this report, considered a part of the Altamaha formation. The beds above the fossiliferous Miocene marl at Doctortown are tentatively referred to the Altamaha formation, although they may be Pleistocene terrace deposits.

"Superb exposures of the Lafayette, displaying the usual fall line features, occur on Savannah River about Augusta. The characters and structural relations here represent those exemplified at Columbus and Macon, save that the "second bottom" phase of the Columbia is replaced by a series of sandy terraces running up into the prevailing coastal sands." (p. 484.)

It is probable that both Pleistocene and Eocene deposits at Augusta have been mistaken for the Lafayette. The Pleistocene beds are described on page 433 of this report.

Sunhill and Munnerlyn are mentioned by McGee as localities where the Lafayette may be observed. The materials at both localities appear to be identical in character with those of the Altamaha formation, which is well exposed to the southward of these localities.

In 1891 J. W. Spencer[1] also gave detailed descriptions of supposed occurrences of Lafayette strata in Georgia. The following are quotations from his report, with comments by the writers:

"At Rich Hill, about six miles southeast of Knoxville, the same red loam forms a capping at an elevation of 835 (?) feet; and near by, gravel is seen on the hills at fifty feet below. At both these localities, the loam forms a capping for both the surface and the sides of the hills, where the underlying formations were incised by former eroding streams. This condition is common to the formation, as it forms a sheet alike over the ancient hills and greater valleys. The base of this loam, especially in the vicinity of the greater rivers, passes into a well marked bed of rounded quartz gravel, sometimes three inches in length. Such gravel is seen upon the hills between Knoxville and the Flint River, at elevations of 130 feet above its modern high water. South of Knoxville the red loamy surface is replaced by a belt of loose gray sand."

The red loam capping Rich Hill is probably of Eocene age. The materials at lower levels in this vicinity are in part residual sands and in part Pleistocene terrace deposits.

"The country south of this point is, commonly speaking, a high plain somewhat incised by streams. The surface is generally composed of the orange loam, which varies in thickness from zero to 20 feet, as shown in the railroad cuts south of Gaillard's.

"At Fort Valley, this red loam or clay reaches a depth of 2 feet, as shown in the artesian well. About three miles south of Fort Valley, there is an excellent exposure in the railroad cut on the road to Americus.

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[1]First Report of Progress of the Geological Survey of Georgia, 1891, pp. 60-72.

		Feet
"1.	Deep colored red loam or hard sandy clay, with rounded gravel in the lower two feet, resting upon an eroded surface	6-10
2.	White and red mottled clay with surface eroded	7- 3
3.	Thin laminated sand with clay partings	2
4.	Laminated sand in colors from black to white exposed	10

"No. 1 represents our Lafayette deposit, and I am inclined to place even the lower members as belonging to an earlier episode of that period.

"In a neighboring washout, the red loam has a thickness of ten feet, underlaid by beds of whitish clay from 4 inches to 2 feet thick, intercalated with sand beds. Some of these sands are deep red, and others gray or white; beneath the whole are white sands. This section reaches a total thickness of about 25 feet.

"From Fort Valley southward, the level plateau is covered with the red loam of argillaceous texture. West of Winchester, sections of this superficial material are well shown, where about eight feet of orange clayey sand rests upon laminated sands in white and colored bands. Upon the higher plateau, above Montezuma, the red loams prevail; but in descending to the Flint valley, the underlying gray sands form the surface soils. This is true over the lower country about Montezuma, and, indeed, for many miles in the direction of Americus. But the higher hills are everywhere capped with the orange loam.

"Along Flint River, many sections of the Lafayette loam are seen forming the bottom lands. The best section, in its relation to other rocks, is shown about two miles south of the great bend, in the river in closest proximity to Everett station. That section is here given.

		Feet
"1.	Orange loam or sandy clay	8
2.	Light bluish clay with irregular joints stained red	6
3.	Orange and gray clayey sand, unconformable above and below	5-9
4.	Coarse light bluish clay, unconformable above and below	3
5.	Orange-colored quartz gravel, unconformable above	10
6.	Coarse white sand cemented with clay, exposed	4

"The upper three members and the fourth member represent two distinct episodes, as shown by the unconformity. At the ferry, between Winchester and Garden Valley, the mantle of orange loam is well developed, reaching from near the river to the surface of the country 210 feet above it, this occupying alike the hill and the old valley. Here, the deposit is of a more sandy character than adjacent to Fort Valley, and the lower beds are cemented into occasional blocks of ferruginous sandstone."

The deep red materials forming the upland surface at Fort Valley and southward to the vicinity of Montezuma are in this report considered of Eocene age, and probably referable to the Claiborne group. The materials on the low plains bordering Flint River from Montezuma up the river to Everett Station are Pleistocene terrace deposits.

LAFAYETTE AND COLUMBIA MANTELS IN THE CHATTAHOOCHEE VALLEY

"In the vicinity of Columbus, both the Lafayette and Columbia formations are best shown in the railway cut, and in the ravines upon the Alabama side of the river. The upper of these consists of about ten feet of red loam underlaid by from one to four feet of coarse gravel. This formation rests

upon the eroded surface of the Tuscaloosa series. The Columbia series rests unconformably upon the older and constitutes the plains at Columbus, which rise about one hundred feet above the river and 260 feet above the sea. This later formation is made up of bluish sand and alluvial clay. About five miles south of Columbus, just beyond Upatoi Creek, on the road to Cusseta, there are other fine exposures of the older deposits.

	Feet
"1. Orange loam	10
2. Laminated, colored sands with a streak of whitish clay; this bed is completely cut through by the valley of an ancient branch about twenty feet wide, which is now filled with the over-lying red or orange loam	6
3. White and stained clayey coarse sand	8
4. Gray sandy clay	6

"On neighboring hills, the gravels are found at an elevation of about 350 feet above the river, which is two or three miles distant.

"At many points along the Chattahoochee River, this orange loam capping is characterized by drift logs at its base; these probably belong to the younger system of deposits, although sometimes of a different color from those at Columbus.

"Steward's Hill, six miles north of Georgetown, displays the finest exposures of the Lafayette series seen anywhere in Georgia. This hill rises 265 feet above the river; the lower 145 feet belong to Cretaceous beds; the overlying 120 feet constitute the Lafayette sand or loam.

	Feet
1. "First bench of loamy sand, drab or reddish; the lower three inches cemented with iron	30
2. Second bench, like the first, with sandstone cemented at base	10
3. Ditto of a redder color, but at base there are three feet of sandy clay	20
4. Variegated colored laminated clayey sands	40
5. Ditto partially concealed	20
6. Cretaceous deposits	145

"The lamination is not always well marked. The sands vary from white to red. Through one of the beds there is a layer of coarse pellets, producing a fine conglomerate. In this region, the gravels occur along the sides of valleys tributary to the Chattahoochee, but are not found at Steward's Hill. The gravels appear to be characteristic of the plateau to which Columbus belongs. This condition is shown in the high terrace of Eufaula (125 feet above the river), where there is a thick gravel floor. That terrace is bounded on the west by hills covered with Lafayette loam. At Fort Gaines, a similar condition is found. The surface of the same terrace is covered with twenty feet of red clayey sand or loam, the lower part of which is composed of quartz gravel.

"The railway cuts east of Georgetown expose excellent sections.

"Along the river, about four miles above Columbia, Alabama, a fine exposure of orange loam was seen rising twenty or thirty feet above the river. In this loamy deposit, a piece of gneiss was found, in size 8 to 6 by 4 inches, and some smaller pieces of mica schist. These transported stones could not have been brought from a point nearer than Columbus, seventy-five miles distant in a straight line. They could not have been transported by waves, but were probably carried southward entangled in the roots of driftwood.

"The terrace in the extreme southwest corner of the State, near Chattahoochee village, has approximately the same altitude as at Columbus and Fort Gaines. Its surface and sides are covered, throughout a vertical range, of one hundred feet, with the same orange-colored sandy clay or loam.

"From these descriptions, it will be seen that orange-colored or red sandy loam extends througnout the whole length of the river from the highest altitudes of the country to the present flood plains."

The deposits on the plains bordering Chattahoochee River at Columbus, Eufaula, Georgetown, and Fort Gaines are Pleistocene terrace sediments which rest directly upon Cretaceous, Eocene, and Oligocene strata. There is question as to the age of some of the gravels on the upland east of Columbus, but since gravel beds are known in both the underlying Lower Cretaceous beds and in the Eutaw formation of the Upper Cretaceous, it is considered probable that they are all of Cretaceous age. The section at Stewards Hill is referable in its entirety to the Ripley formation of the Cretaceous.

"LAFAYETTE AND COLUMBIA MANTELS IN THE INTERIOR OF SOUTHWEST GEORGIA

"Throughout the highlands of Decatur and Thomas counties conditions similar to those along the great rivers prevail. Thus, near Whigham station we see the following section:

		Feet
"1.	Orange or red loam passing beneath into a lighter and more clayey layer	4- 8
2.	Redish and light colored mottled clayey sand with light patches of clay; only the upper portion is laminated; the lower part is somewhat sharply defined, and in other places apparently passes into	8
3.	Laminated white and purple clay with red micaceous and sandy partings. This bed shows undulations	3
4.	Laminated red sand with clayey partings	6

"No. 1 belongs to the Columbia and possibly to the No. 2 and No. 3 Lafayette series. In the Attapulgus Creek district, the orange or red loam varies from two to eight feet, and often passes imperceptibly into bluer clay, which occasionally graduates into banded clay.

"On the Tnomasville road, nine miles east of Bainbridge, the orange loam is conspicuous. There, a rolling hill-country, covered with this red deposit, bounds the sand-covered plains of Bainbridge. In a washout, the lower portion of the loam, which is 8 or 10 feet thick, contains irregular pockets of cherty fragments derived from the adjacent rock. At one point, this loam rests upon blue clay. In some localities, this subjacent clay is seen; at others the underlying material is quicksand. The explanation of this condition was not obtained until the observation was made in the railway cut about a mile west of Climax, on the road to Bainbridge, showing the following section:

		Feet
"1.	Orange or red loam passing below into a red and white clayey material, with some ferruginous concretions	4-12
2.	Laminated sands, in colors from white to black, with clay film partings	0-12
	At the west end of this section the sand is traversed by two seams of white clayey matter about 8 inches thick. It rest upon the eroded surface of	
3.	Whitish sandy clay	4-8
4.	A hand of sand from white to dark red in color with some slightly clayey seams; exposed in places	8
5.	Miocene, white sandy clay, exposed	0-16

"No. 2 is wanting at the eastern end of the cut, but No. 1 rests upon from 10 to 15 feet of a sandy clay (Miocene) No. 5 which is not exposed at the western end of the section. Two unconformable deposits succeed the Miocene; but the lower of the two is sometimes completely wanting. Thus is explained the occassional absence of the sand, which is so often seen beneath the loam; namely, on account of its entire removal by erosion, before the deposition of the superficial red loam.

"In many places, in these southern counties, the orange loam rests directly upon the deposits of apparently Miocene age. On the higher lands, the loam is not covered by any superficial material, but at elevations inferior to 200 feet above the sea, a superficial water washed sand (Columbia series) may be seen, at many places, resting upon the loam. This superficial sand, at the phosphate beds, west of Boston, has a depth of a foot and a half. Throughout the lower and more level counties of Mitchell, Miller, Baker, Dougherty and Calhoun, the loam is apt of itself to be sandy, and covered with a sandy soil, either directly derived from the loam, or perhaps indirectly by the waves acting temporarily in some lagoon, which may formerly have covered these counties. This last explanation appears to be sustained by the presence of duny sand ridges rising to a height of twenty feet, on the east side of the Flint River, opposite Newton.

"A further characteristic of this orange or red sandy clay or loam is that its lower portion consists of a bed of gravel, in the vicinity of the ancient valleys. Thus, on the hills, above the last bridge over the Upatoi Creek, the gravel occurs at an elevation of 350 feet above the Chattahoochee River, which is two or three miles distant. These pebbles diminish in importance on going southward, and were not seen near the Florida boundary. But, as if to take their place, fragments of limestone, or in phosphatic regions, pebbles of phosphate occur in portions of the beds. In this way the character of the subjacent rocks is detected by the hillocks being covered with such loose masses, secondarily derived from the drift.

"As was noted before, at one or two points along the Chatahoochee, drift boulders from the crystalline rocks far away were found. The same holds true along the Flint and in other regions. This evidence of partial transportation of the material of the loam is not needed to explain its source; for it is generally so charged with hydrated micaceous particles as to at once tell that a considerable portion of it has been derived from the decayed crystalline rocks of Middle Georgia; which had also contained the quartz veins, whence the quartz pebbles, in the gravelly portions of the formation, originated. However, their partial local origin is attested by the presence in many localities of fragments of the subjacent rocks."

The deposits in southwestern Georgia referred by Spencer to the Lafayette formation are included in the present report in the Altamaha formation.

In 1898, in connection with his study of the clays of the Fall Line region, Dr. Geo. E. Ladd[1] made some observations on supposed Lafayette strata, occurring in the Fall Line region. Following the theories advanced by McGee and Spencer, Ladd assumed that the Lafayette formation was a surficial deposit which covered the entire Coastal Plain.

"THE COLUMBIA AND LAFAYETTE FORMATIONS"

"The formations of the Cretaceous and Tertiary succeed each other, without any long continued land intervals, geologically speaking; and,

[1]Clays of Georgia: Geol. Survey of Georgia, Bull. No. 6-A, 1898.

in spite of the unconformities mentioned, they rest, one on another, in a generally conformable series. At the close of the Miocene Period, however, South Georgia stood for a long time high above the sea, the great rivers carved broad and deep valleys, cutting down, in places, to a depth of 350 feet below the general surface level, for a breadth of several miles, the topographic features of the region becoming pronounced. (p. 88.)

"Following this land epoch, however, came a new subsidence, the shoreline moving inland to the present Fall Line, and, in places, somewhat beyond it. During this subsidence, when elevations, now 800 feet above the level of the sea, were washed by its waves, deposits of sand, clay and gravel were spread irregularly, sometimes to the depth of 150 feet like a huge mantle over the hills and valleys, which had been carved out, during the land epoch. The materials of this formation can be found all over southern Georgia. They rest on the hill-tops, on their slopes, and on the floors of the valleys, and greatly interfere with geological research. This formation is known as the Lafayette. (pp. 88-89.)

"After a comparatively brief subsidence, there was re-emergence, when new valleys were cut, often through the Lafayette, and penetrating the underlying strata. Then took place a final submergence and a deposition of the superficial sands and gravels, which make up Columbia formation. The Columbia and Lafayette formations are unconformable with reference to each other; they also lie unconformably upon the Tertiary and Cretaceous strata; and along the margin of the Coastal Plain even upon the crystallines of the Piedmont Plateau. * * * (p. 89.)

"The Lafayette gravels are characterized by cross bedding, rapid transition from coarse to fine material, and generally, by a deep-red color, resulting from the oxidation of iron-bearing material. It frequently has a mottled appearance which is noticeable in the sides of gullies and cuts. The prevailing red color is frequently broken by a net-work of gray and blue tints, which mark the former position of the roots of trees and shrubs where the iron oxide has been "reduced" by the organic compounds resulting from their decay." (p. 90.)

Ladd states that Rich Hill, Crawford County, is capped with Lafayette strata (p. 91). As previously stated, the red materials on this hill are probably of Eocene age.

"The Fall Line crosses the Ocmulgee River beneath the Macon footbridge; and here are exposed boulders and outcropping ledges of the hard Piedmont crystallines. Overlying them are the Columbia terraces; and east and west mounting over, but capping, the Tertiary heights are the white, red and orange gravels and sands of the Lafayette. (p. 101.)

The thought expressed is that the terrace materials belong to the Columbia division of McGee, and that the Lafayette formation is confined to the heights and rests upon Tertiary strata. As previously stated, the gravels and red loams on the upland at Macon overlie Cretaceous strata and probably belong to the Claiborne group of the Eocene.

Gravel deposits occurring at Vineville and at Rutley [Rutland] are referred by Ladd to the Lafayette formation (pp. 102, 103). In the present report these are considered terrace deposits belonging to the Okefenokee formation (Pleistocene).

Ladd also described sands and gravels which he considered referable to the Lafayette formation, at Griswoldville, Jones County

(p. 106); at Gordon; at McIntyre, Wilkinson County (pp. 120, 130); at Stevens Pottery, Baldwin County (pp. 138, 139); at Chalker, Washington County (p. 151); and near Belair, Richmond County (p. 161). These materials are said to form mantles over Cretaceous or Tertiary strata, or over both. After having studied many exposures in this region the present writers have reached the conclusion that Ladd has mistaken for the Lafayette formation both Eocene and Cretaceous strata in place, and the residual creep materials derived from these strata. This opinion is based partly upon paleontologic evidence and partly upon the lithologic resemblances of the supposed Lafayette materials to the Eocene and Cretaceous strata of the region.

R. M. Harper[1] has discussed the occurrence of supposed Lafayette deposits in Georgia as follows:

"When thoroughly decomposed by atmospheric agencies the Grit can often hardly be distinguished from the Lafayette loam, and in railroad cuts and other artificial excavations which exposes the indurated Grit it is sometimes impossible to say whether there is any Lafayette above it or not.

"The Lafayette probably covers more than 99 per cent. of the Altamaha Grit region, but its presence cannot easily be proved, for the reason just stated, and also because neither it nor the Grit is fossiliferous. Little if anything is known as to its maximum thickness in this region. In composition it is a loam, containing probably as much sand as clay. Farther inland it is often brick-red, but in the Altamaha Grit region, and in pine-barrens generally, its color is considerably lighter and might be described as terra-cotta."

Although assuming that the Lafayette formation is present as a surficial covering over practically all of the Altamaha region, Harper admits that "its presence can not easily be proved." The present writers have not been able to differentiate any surficial formation other than residual gray sands and the Pleistocene deposits which along the rivers and towards the coast rest upon the Altamaha beds as terrace accumulations. In their opinion the loams referred to the Lafayette formation by Harper are the weathered residual products of the Altamaha strata.

The following description of the Lafayette is given by Professor McCallie:[2]

"*Lafayette.*—The Lafayette, whose exact position in the geologic time scale is still debated, like the Columbia formation, is a superficial deposit, covering most of the Coastal Plain. The formation consists of orange and vari-colored clays and sands, with local beds of gravel. The basal member of the formation along the Fall Line frequently becomes distinctly pebbly. These water-worn pebbles, which consist largely of quartz derived from the crystalline rocks to the north, occur irregularly distributed throughout the

[1]Annals New York Acad. Sci., Vol, 71. pt. 1, 1906. p. 23.
[2]Geol. Survey of Ga., Bull. 15, 1908, p. 30.

vari-colored sandy clays, but more often they are found in layers or pockets. They also occur in the basal member, at places, with fragments of white clay forming more or less continuous layers. These phases of the lower division of the formation become less pronounced in the southern part of the State, where sandy loam and vari-colored stratified clays predominate.

"The upper member of the formation differs from the lower in being more uniform, both in physical structure and lithological character. Along the Fall Line, at some points, it becomes quite pebbly; however, as a general rule, it is made up almost entirely of massive reddish or motley sandy clays. Frequently, the massive clays of the upper division are hardened into a compact mass, having almost the consistency of sandstone. This indurated layer resists the erosive action of surface water; and, by being undermined by the washing away of the layers below, it often stands out in high, perpendicular walls. Excellent illustrations of this mode of erosion are frequently met with in the vicinity of streams, which have lowered their channels into the underlying formations.

"The thickness of the Lafayette formation is quite variable. At some places, near the northern margin, where it has been protected by the Columbia sands, it attains a maximum thickness of more than 80 feet; at other points, it has been entirely removed by erosion. These eroded areas are quite irregular in outline, and may occur at any point throughout the Coastal Plain. They are more frequently met with, however, in the vicinity of the larger streams; yet, they are not entirely absent from the level piney woods."

Following McGee and others, McCallie has referred to the Lafayette formation deposits both older and younger than Pliocene.

In the opinion of the writers the existence of the so-called Lafayette formation in Georgia has not been proven. Assuming the terrane to be of Pliocene age, it is probable that at least a part of the beds referred in this report to the Altamaha formation are synchronous with it. Other than these the formation probably has no representatives in Georgia.

CHARLTON FORMATION

The name Charlton is derived from Charlton County Ga., and is applied to an argillaceous limestone and clay formation exposed in the banks and bluffs of St. Marys River, from Stokes Ferry, 11 miles south of St. George, Charlton County, Ga., to Orange Bluff, near Kings Ferry, Fla. This formation, however, may also occur on the Satilla River[1] and the probability of limestone beds at Burnt Fort, 12 miles northeast of Folkston being equivalent, has been mentioned on a preceding page. From a study of the fossil collections from St. Marys localities, Dr. Vaughan has classified the formation as probably of Pliocene age.

In previous publications there are a few scattered references to the formations exposed along St. Marys River, but the authors have

[1]NOTE.—A fossiliferous marl has recently been found near the Satilla River, on the land of W. M. Thrift, six miles east of Winokur, Charlton County. It resembles some of the marl on St. Marys River and is of probable Pliocene or Miocene age.—O. V.

A. EXPOSURE OF CHARLTON FORMATION, ST. MARYS RIVER, (FLORIDA SIDE), ONE MILE ABOVE TRADERS HILL CHARLTON COUNTY, GA.

B. CHARLTON FORMATION, ST. MARYS RIVER, AT A. C. L. R. R. BRIDGE, THREE MILES SOUTHEAST OF FOLKSTON, CHARLTON COUNTY, GA.

made little or no attempt at correlation. The relations of the Charlton formation to other formations on St. Marys River are graphically shown in the profile, fig. 4, page 47.

The relations of the Charlton formation to the Miocene are not definitely known. At Stokes Ferry the top of the formation is perhaps 30 or 35 feet above sea level, and it descends gradually down stream, reaching tide level. According to the geological map of Florida by Matson and Clapp the Jacksonville formation (Miocene) outcrops at elevations of [illegible] feet above sea level, a short distance south and east of St. Marys River. [illegible] from which Dr. Vaughan has identified Miocene fossils are exposed at low tide at [illegible] Ferry, Satilla River, Camden County, Ga. In view of these occurrences of Miocene the Pliocene beds on St. Marys River, if [illegible] Miocene strata, [illegible] may rest in a similar [illegible] Alum Bluff formation [illegible] Miocene [illegible] Miocene [illegible] There [illegible] 12 or [illegible]

[illegible]

[illegible]

[illegible]

made little or no attempt at correlation. The relations of the Charlton formation to other formations on St. Marys River are graphically shown in the profile, fig. 4, page 47.

The relations of the Charlton formation to the Miocene are not definitely known. At Stokes Ferry, the top of the formation is perhaps 30 or 35 feet above sea level, and it descends gradually down stream, reaching tide level. According to the geological map of Florida by Matson and Clapp[1] the Jacksonville formation (Miocene) outcrops at elevations of 50 to 100 feet above sea level, a short distance south and east of St. Marys River. Beds, from which Dr. Vaughan has identified Miocene fossils, are exposed at low tide at Owens Ferry, Satilla River, Camden County, Ga. In view of these occurrences of Miocene the Pliocene beds on St. Marys River, if correctly correlated, may occupy an erosion basin in Miocene strata, or, if the latter are absent beneath them, they may rest in a similar basin in pre-Miocene strata probably referable to the Alum Bluff formation (Oligocene). The great thickness[2] attributed to the Miocene at Jacksonville, 460 feet, and the fact that the Miocene there is supposed to lie unconformably upon the Vicksburg, makes the former alternative seem the more probable one. There are no data for estimating the thickness of the formation; only 12 or 15 feet have been observed in natural exposures.

The strata are poorly fossiliferous, and it is difficult to correlate the beds on the basis of their fossil contents. The formation is characterized at two or three localities by an abundance of ostracods. All of the fossils which have been identified from the formation are given on succeeding pages.

Regarding the age of the formation, Dr. Vaughan, in unpublished notes, says:

> "None of the material [fossils] between Hicks Bluff and Orange Bluff can be older than Pliocene, and although not a single extinct species was collected, it may be Pliocene. The two species of ostracods listed by Doctor Bassler from Rand Landing and Clay Landing appear to be recent. As the material from Stokes Ferry seems to be the same as that from Rand and Clay landing it is probably of the same age. [Pliocene.]"

LOCAL DETAILS

ST. MARYS RIVER.

Stokes Ferry.—The point farthest up St. Marys River at which hard rock of the Charlton formation appears is at Stokes Ferry, 11 miles south of St. George, Ga. The exposure is in a low bluff on the Florida side, about 100 yards below the ferry. Orange-colored loam

[1] Second Ann. Rept., Geol. Survey of Florida, 1909.
[2] Idem.

overlain by gray sand appears in an escarpment a short distance back from the river at a higher level than the strata described in the following section:

Section at Stokes Ferry

Pleistocene		Feet
Satilla formation.		
4.	Dark colored sand; contains vegetable matter; thickness variable	4
3.	Coarse, greenish, argillaceous sand. Line of rounded, flat, or discoidal quartz pebbles, some as much as two inches in diameter, along base	2
	(Unconformity)	
Pliocene ?		
Charlton formation.		
2.	Greenish or drab, stiff, tenacious clay containing calcareous concretions; ostracods and some phosphatic particles, maximum	4 to 5
1.	Limestone containing ostracods, small gastropods, and casts of small bivalves	1

The limestone at the base is a hard, spongy, or cellular, siliceous rock; about one foot is exposed at low stages of the river. Beds Nos. 1 and 2 appear for about 150 or 200 feet along the river bank beyond which they are replaced by the more recent Pleistocene. Loose fragments of bones and mammal teeth were found here, and from their position on the slopes of the bluff it is inferred that they came either from bed No. 2 or bed No. 3.

Hicks Bluff.—Except at one point only late Pleistocene sands and clays are exposed at this locality; however, the orange-colored, argillaceous sands, which in this region overlie the Charlton formation, appear in an escarpment leading to the higher land about 300 yards back from the river.

Section at Hicks Bluff

Pleistocene.		Feet.
Satilla formation.		
3.	Dark-colored, thin line of quartz pebbles at base .	3 to 10
	(Unconformity)	
Pliocene ?		
Charlton formation.		
2.	Greenish, sticky, sandy clay, maximum	4
1.	Soft, argillaceous, fossiliferous limestone; contains *Pecten gibbus*, *Phacoides multilineatus* and *Laevicardium*, maximum thickness	4

The limestone and clay appear as a small erosion dome covered by late Pleistocene sand. The limestone is richer in fossils than at any other locality on the river. A few fragments of bones and mammal teeth were found.

No exposures of hard rock are known between Hicks Bluff and Red Bluff.

Red Bluff.—The section at Red Bluff on the Florida side of the river, two miles east of St. George, Ga., is described as follows:

Section at Red Bluff.

	Feet
Pleistocene?	
4. Partly concealed, and in part gray sand	10
3. Vari-colored sand	26
Pliocene ?	
Charlton formation.	
2. Drab, sandy clay	7
1. Sandy, fossiliferous limestone	1.5

From the limestone bed Dr. Vaughan has identified the following fossils:

Fossils from limestone bed at Red Bluff.

Leda acuta Conrad.
Barbatia marylandica Conrad.
Arca umbonata Lamarck.
Pecten sp.
Lithophaga sp.
Phacoides or Diplodonta.

Schoolhouse Bluff.—A section similar to the preceding is exposed at Schoolhouse Bluff, about four miles below the Georgia Southern and Florida Railroad bridge, and one mile below old Drewry Ferry.

Section at Schoolhouse Bluff.

	Feet.	In.
Pleistocene.		
7. Gray or white sand at top of bluff	4 to 5	
6. Orange-colored, argillaceous sand with clay at the base, and beneath the clay a thin line of small quartz pebbles	12 " 15	
Pliocene ?		
Charlton formation.		
5. Greenish, fine-grained, sticky clay	3	
4. Soft limestone, and siliceous, fossiliferous material with ostracods and *Rangia cuneata*	1	
3. White, calcareous clay	3	
2. Hard, earthy, argillaceous limestone	0	4
1. Chalky, argillaceous limestone with small gastropods	2	6

Rand Landing.—This bluff is located about two miles below the old Drewry Ferry, and about five miles, by land, below the Georgia Southern and Florida Railroad bridge.

Section at Rand Landing.

	Feet	In.
Pleistocene?		
12. Poorly exposed orange-colored argillaceous sand; line of small quartz pebbles along base	20	

		Feet.	In.
Pliocene ?			
Charlton formation.			
11.	Clay (?)	4 to 5	
10.	Thin, nodular, limestone layer		
9.	Greenish clay		
8.	White and greenish laminated clay with poorly preserved prints of fossils	0	4
7.	Greenish, laminated clay	1	6
6.	Cream-colored, argillaceous limestone	0	6
5.	White, calcareous clay	2	
4.	Soft calcareous material containing ostracods, *Bythocypris*, *Cytherella*	1	
3.	Limestone, non-fossiliferous	0	10
2.	White, calcareous clay	2	
1.	Rather hard, argillaceous limestone	2	10

Stratum No. 1 is apparently arched into a small anticline. It appears at the water's edge at two points about 100 yards apart, and halfway between these two points it rises about three feet above the water.

Clay Landing.—This bluff is on the Florida side of the river and about one and one-half miles northeast of Toledo, Ga.

Section at Clay Landing.

		Feet
Pleistocene (?).		
5.	Slope covered by gray sand; underlying strata probably orange-colored, argillaceous sand	15 to 20
Pliocene ?		
Charlton formation.		
4.	Contact with the above not exposed. Greenish, fine-grained, sticky or plastic clay containing small, calcareous nodules,—exposed	5
3.	White clay	2
2.	Soft, friable, calcareous, sandy clay or marl; contains ostracods, poor casts and prints of mollusks, fish teeth and fish vertebrae	3
1.	White, hard, argillaceous limestone, no fossils	1

Two ostracods, *Bythocypris* sp. and *Cytherella* sp. have been identified from bed No. 2. According to Dr. R. S. Bassler these species are either Recent or close to Recent species.

Nettles Landing.—There is a high bluff at an old log slide one and one-half miles by land above Cow Ford. The strata are not very well exposed.

Section at Nettles Landing.

		Feet
Pleistocene?		
11.	White, surficial, quartz sand at top of bluff	3 or 4
10.	Not well exposed, slope covered with white sand; probably an orange-colored, argillaceous sand underlies the surface, line of small, well-rounded	

	Feet
quartz pebbles at base from which springs emerge	15 to 20
Pliocene ?	
Charlton formation?	
9. Poorly exposed, plastic, greenish, fine-grained clay	3
8. Concealed	5
Charlton formation.	
7. Thin layer of hard, argillaceous limestone, probably but a few inches thick	?
6. Clay	4
5. Thin limestone layer with a few poor prints o. fossils	2
4. Drab, laminated clay	
3. Soft, sandy, argillaceous limestone, *Modiolus*, *Cy thereaf*, *Rangia*	5
2. White, hard limestone—no fossils	
1. Earthy, compact limestone	

Stratum No. 11 is a part of the gray or white surficial sand covering the upland plain. The river at this point impinges against the scarp of the Okefenokee plain or plateau, and the late Pleistocene or Satilla terrace deposits do not appear, which accounts for the difference in the height of this bluff as compared with the bluffs at Sawpit Landing and Cow Ford.

Stratum No. 10 is probably the equivalent of the upper parts of the bluffs at Calico Hill and near Folkston.

Cow Ford.—The next exposure of the argillaceous marl or limestone of the Charlton formation appears in the right bank of the river about one-half mile below Cow Ford and nine miles south of Folkston.

Section at Cow Ford.

	Feet
Pleistocene or Recent.	
4. Dark or chocolate-colored sand, white at the surface	5
Pliocene ?	
Charlton formation.	
3. Plastic, sandy clay	
2. Soft, yellow, argillaceous limestone; contains poorly preserved fossils—*Modiolus*, *Pnacoides* *Carditamera* sp.	4
1. White, laminated, fine-grained clay	

The lowest Pleistocene terrace, which at this point is a palmetto "flatwoods," is about three-fourths of a mile wide. It lies 10 to 15 feet above low water; at its inner margin there is an abrupt rise of about 30 or 40 feet from this lower plain to the upland plain.

Sawpit Landing.—Calcareous clay and chalky limestone are exposed at this locality, two miles by the river above the ferry at Traders Hill.

Section at Sawpit Landing.

	Feet	In.
Pleistocene.		
Satilla formation.		
8. Stiff, greenish clay	3	
(Unconformity)		
Pliocene ?		
Charlton formation.		
7. White, calcareous clay	1	
6. Calcareous sand and sandy limestone	0	6
5. Soft, white, calcareous clay, fossiliferous; contains *Leda*, probably *acuta*, *Pecten gibbus*, *Anomia simplex*, *Phacoides* or *Diplodonta*, *Tellina* sp.	1	
4. White or yellow limestone	1	
3. Greenish clay	1	
2. Drab, calcareous clay	2	
1. Soft, gray or white, chalky limestone or marl at low tide	2	

Bed No. 8 is considered Pleistocene in age; the clay forms a flat terrace about one mile wide bordering the river.

Folkston.—A good exposure occurs three miles southeast of Folkston on the Florida side of the river at the end of the new bridge of the Atlantic Coast Line Railroad. The section in detail is as follows:

Section of bluff on St. Marys River, at end of railroad bridge, three miles southeast of Folkston.

	Feet	In.
Pleistocene ?		
24. At top—gray, fine, incoherent, quartz sand	2	
(Unconformity)		
23. Mottled clay and sand	4	6
22. Stiff, plastic clay	3	6
21. Orange-yellow, clayey sand	5	6
20. Yellow sand	4	
19. Drab, sandy clay	4	
18. Yellow sand	2	6
17. Greenish, stiff, sandy clay with line of quartz pebbles at base	4	6
(Unconformity)		
Pliocene ?		
Charlton formation.		
16. Greenish, laminated clay	1	
15. White limestone layer	0	4
14. Drab, calcareous clay	0	8
13. Limestone	0	3
12. Drab clay	0	6
11. Greenish, laminated clay	1	6
10. Gray, fossiliferous, sandy clay or phosphatic marl; *Pecten gibbus*	1	

		Feet.	In.
9.	Thin layer of compact, argillaceous limestone . .	1	
8.	Green or drab, highly fossiliferous clay, ostracods and clay casts of fossils	2	6
7.	Limestone	0	3
6.	Green, fossiliferous clay, *Pecten*	1	
5.	Limestone	0	6
4.	Clay	0	4
3.	White limestone	0	6
2.	Laminated, fossiliferous clay	2	6
1.	White, argillaceous limestone	0	6

The beds from 17 to 23 inclusive lie horizontally, and are probably of Pleistocene age; from 1 to 16 the strata belong to the Charlton formation. These beds have been disturbed from their original positions and dip northward 30 to 45 degrees. Bed No. 24, the surficial sand which covers the flat, upland plain reaches a thickness of eight feet or more, and is sharply defined from the underlying, red, argillaceous sand, being quite different in lithologic appearance; it is, therefore, considered a later deposition. About 50 yards east of the bridge there is a friable, coquina-like layer, possibly the equivalent of No. 10 of the above section. Of the fossils collected from the Charlton formation at this locality Dr. Vaughan has identified the following:

Fossils from the Charlton formation three miles southeast of Folkston.

Pecten gibbus Linnaeus
Anomia simplex d'Orbigny
Rangia cuneata (Gray)

Limestone or marl is reported at the base of the bluff at Calico Hill, two miles below the bridge; when visited this was not exposed. The bluff or hill is about 40 feet high and the strata exposed are the equivalents of the upper 30 feet of the section at the railroad bridge, with the possible exception of the bluish, fine-grained, plastic clay seen near the base of the hill.

Between the preceding exposure and Chalk Bluff, a section of which is given below, only late Pleistocene sand and clay appear in the river banks.

Chalk Bluff.—This locality is about one-half mile above Orange Bluff, described below, and exhibits a similar succession of strata.

Section at Chalk Bluff.

	Feet	In
Pleistocene.		
Satilla formation.		
5. Bluish or greenish, fine-grained, plastic, sandy clay	2	

		Feet	In.
Pliocene ?			
Charlton formation.			
4.	Stiff, white, chalky or calcareous clay, thin layers of limestone	2	6
3.	Greenish or drab, fullers earth-like clay	1	
2.	White, chalky clay	2	
1.	Sticky, greenish, calcareous clay	1	

Stratum No. 5 underlies a flatwoods terrace, as at Orange Bluff. Poorly preserved fossils occur in the lower part of the bluff. A *Pecten* and probably a *Modiolus* were identified.

Orange Bluff.—This bluff is on the Florida side of St. Marys River, about two miles above Kings Ferry, Fla. It is a low bluff,—about 10 feet high at low tide. The fossiliferous limestone of the Charlton formation is not exposed on the river below this point:

Section at Orange Bluff.

		Feet	In
Pleistocene			
Satilla formation.			
2.	Stiff, greenish, sandy clay, weathered brownish; contains *Ostrea virginica*; thin line of smooth, perfectly rounded quartz pebbles, reaching one inch in diameter, at base	5	
	(Unconformity)		
Pliocene ?			
Charlton formation.			
1.	Soft, white or drab, argillaceous limestone or marl, becoming more argillaceous at the top. The rock is variable in hardness and the river has washed out small holes at the base of the bluff. Fossils collected. Thickness at low tide	4	6

Stratum No. 2 forms the clay flatwoods terrace which borders the river. The fossils in stratum No. 1 are poorly preserved, but are most abundant at the base of the bluff and can be collected best at low tide. From the collections made at this locality Dr. Vaughan has identified the following:

Fossils from Orange Bluff.

Leda acuta Conrad
Pecten gibbus Linnaeus
Fragum
Laevicardium
Phacoides multilineatus (T. and H.)
Chione cancellata (Linnaeus)
Mulinia lateralis (Say)

ALTAMAHA (LAFAYETTE) FORMATION

NAME

The first description of beds which probably included parts of this formation was given by Dr. R. H. Loughridge[1] in 1884, in the Tenth Census, although the name "Altamaha" was not used, and the for-

[1]Tenth Census, vol. 2, 2, p. 15.

mation was described as "Miocene or Grand Gulf" sandstone. The name "Altamaha grit" was applied by Dr. W. H. Dall[1] in 1892, from typical exposures along Altamaha River. Using the name "Altamaha grit," Dr. R. M. Harper[2] studied the formation mainly from a phytogeographical standpoint and gave some details regarding its distribution, lithologic character, and age. He referred it to the Pliocene, and stated "there is every reason to believe that the 'Altamaha grit' is the equivalent of the Grand Gulf formation of the States farther west." Prof. S. W. McCallie[3] has also given a brief description of the deposits. In 1908 Veatch[4] described the deposits, traced their boundaries, and applied to them the name "Altamaha" formation, employing the word formation rather than grit, since so many lithologic phases were discovered to which the term "grit" was not applicable.

As explained on later pages, there is some reason for believing that the deposits here included in the Altamaha formation constitute a complex embracing strata representing every period from the Oligocene to the Pleistocene.

DEFINITION

Stratigraphic Relations.—The Altamaha (Lafayette?) formation has been observed overlying Eocene, Oligocene, and Miocene(?) strata, and may be considered in a certain sense a surficial formation. In Burke and Washington counties in the northeastern part of the Coastal Plain the formation overlaps the Claiborne, some phases of which it resembles texturally; the Claiborne sands, however, bear fossils, upon the evidence of which they may be distinguished from the Altamaha beds. The relations between the two formations may be observed at Waynesboro and Tennille in railroad and road cuts. It overlies the Vicksburg in the counties of Laurens, Pulaski, and Dooly, and is perhaps in contact with the Vicksburg and Chattahoochee in places along the west side of Flint River, as far south as Decatur County. Near the base of the formation there are, in places, mechanically included flint fragments derived from the underlying older formations. The formation probably directly overlies the Chattahoochee and Vicksburg formations in Screven and Burke counties, although actual contacts have not been discovered. Throughout the greater part of the area of its occurrence the formation overlies the Alum Bluff formation from which it can not in

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[1]Bull. U. S. Geol. Survey No. 84, p. 84.
[2]Annals New York Acad. Sci., vol. 17, pt. 1, Sept., 1906.
[3]Bull. Geol. Survey of Georgia No. 15, 1908, p. 31.
[4]Science, n. s., vol. 27, Jan., 1908, pp. 71-74.

all cases be easily discriminated. The two formations are similar lithologically near the contacts at many places, and the Alum Bluff formation does not always bear fossils; it is, therefore, not improbable that beds properly belonging in the Alum Bluff formation have been included in the Altamaha division. Probably a large part of the Altamaha materials were derived from the Alum Bluff beds, rendering the former lithologically similar to the latter. Weathering of both formations has also made a sharp distinction difficult in many localities. Unconformities with the Alum Bluff formation were noted at Climax, Forest Falls, Cairo, and in some of the bluffs on Altamaha River above Doctortown. The relations of the formation to the Alum Bluff formation at particular localities will be discussed in subsequent pages. Beds tentatively regarded as referable to this formation overlie, unconformably, fossiliferous Miocene strata at Doctortown and at Bugs Bluff on Altamaha River and at Porters Landing and other localities on Savannah River.

The relation of the formation to the probable Pliocene bed exposed on the King plantation, six miles south of Atkinson on Satilla River, cannot be determined with certainty, but the latter is believed to be contemporaneous with at least a part of the beds here included in the Altamaha (Lafayette?) formation. In the dredgings at Brunswick, Miocene, Pliocene, and Recent shells were obtained, but there are no natural exposures of the beds and the relations of the Altamaha (Lafayette?) formation to possible Pliocene must remain in doubt.

It has not been possible in all cases satisfactorily to determine the relation of the terrane to deposits of Pleistocene age. In fact, there is some grounds for the belief that the strata here included in the Altamaha (Lafayette?) formation may be a complex, embracing on the one hand not only beds of Pliocene age but also beds of Miocene and Oligocene age, and on the other hand beds of Pleistocene age, the latter being reworked products of the Altamaha materials, and therefore resembling them. However, the evidence at present available is not sufficient to justify an attempt to subdivide the formation.

Overlying the Altamaha (Lafayette?) formation there is nearly everywhere a thin mantle of loose, gray, or brownish sand, mainly of residual origin, but probably in part of Pleistocene age. The sand rarely shows stratification lines, contains but very little clay, and can be easily differentiated from the Altamaha materials. These surficial sands in places reach a thickness of 20 or 30 feet, but the average is not more than two or three feet.

Lithologic Characters.—The Altamaha (Lafayette ?) formation is an extensive deposit of irregularly bedded sands, clays, and gravels, locally indurated. On the whole the deposits are homogeneous, but locally become a heterogeneous mixture of the above mentioned components. The indurated sands and the conglomerates contain a peculiar greenish or greenish-gray, disseminated clay, and are described as "gray or greenish aluminous grits;" the pebbles are predominantly subangular, often lath-shaped, and the sand is universally harsh or in sharp, angular grains; there is a great abundance of feldspar, both in pebbles and semi-decomposed, disseminated grains, and phases of the formation may be appropriately described as "feldspathic grit"; a negative peculiarity is the total absence of calcareous phases. The weathered surface loams are mottled and splotched in red, yellow, purple, and gray tints, the surface aspects differing in this respect from those of any other Coastal Plain formation. These striking effects are probably due to unequal weathering, oxidation, and unequal distribution of iron materials. These loams are not a later deposition but are due to the weathering of the Altamaha materials, although in many places they appear to overlie unaltered beds unconformably. The formation is very coarse-grained, even at points 100 miles from its northern margin. It contains sands, gravels, conglomerates, and clays, all of which are locally indurated; the sandstones, conglomerates, and claystones do not differ essentially in composition from the non-indurated materials. These different phases do not constitute stratigraphic units but are local depositional phases produced by shifting currents.

The grit and sandstone phases of the Altamaha (Lafayette ?) formation, the peculiar nature of which attracted the special attention of those who first studied the terrane, are typically exposed along Altamaha River. They appear as gray or greenish, aluminous sandstones, more or less mottled and stained by iron oxide. At some localities pebbles are embedded in the sand and clay matrix, the whole cemented into a conglomerate; but, except for the pebbles, these beds do not appear different from the typical sandstone of the Altahama formation. The percentage of clay in the indurated rock varies from five to ten per cent. to a percentage sufficiently high to render the rock an indurated clay rather than a sandstone. The sandstones are generally soft and friable, the cementing material being an opaline silica, but locally they become extremely hard. In places the sandstones are arkosic,—that is, composed of quartz, feldpar, mica, and other minerals of igneous rocks,—in which cases the interstices are filled with clay and the whole cemented with silica, producing rocks not un-

like some of the indurated phases of the Lower Cretaceous strata near the Fall Line. These lithologic peculiarities have been observed at widely separated localities, the sandstones being in all cases easily identified, although entirely devoid of fossils. Except along Altamaha River, surface outcrops are not abundant. In the interstream areas there are occasional small tracts a few acres in extent, in which jutting beds of sandstone, 15 or 20 feet thick, form barren, rocky flats. Exposures of grit or hard rock are most common in the northern part of the Altamaha region but are not observed near the coast or near the Florida boundary line. It is believed that these isolated exposures are local indurations only and do not form continuous sandstone beds.

The clays of the Altamaha formation are fairly uniform in texture and composition throughout the area of their occurrence. They are greenish or drab, very fine-grained and plastic, and always more or less sandy. They have a low specific gravity absorb a high percentage of water, and occur in thick, irregular pockets or thin, lenticular layers, never persisting as individual beds over any large area. In places they grade into or are abruptly replaced by sands and sandstones. Greenish clay, full of coarse, angular, quartz particles and subangular, decomposed, feldspar pebbles, is of frequent occurrence in the formation. The clays are locally indurated, the cementing material being opaline silica.

The sands of the formation consist chiefly of coarse, quartz sand and are red and yellow, or orange, in color, with an occasional brownish tint. They are more or less argillaceous and in places contain layers of quartz and feldspar pebbles. The feldspar pebbles constitute a large percentage of the gravel layers. A characteristic of the pebbles is their angularity, some being lath-shaped, showing scarcely any rounding of the angles. The pebbly feature is nowhere very prominent and is exceptional rather than general. In a few localities the pebbles are rather large, attaining a diameter of four or five inches. Near the Atlantic coast and in the southwestern part of the State the sands are, in places, fine-grained, rarely micaceous, crossbedded, and interstratified with thin layers and leaves of plastic clays. In places these clay layers do not exceed one inch in thickness. Such a structure is seen in the exposures of the formation near Jesup, at Waynesville in Wayne County, and near Whigham in Grady County.

In the northern part of the region the sands are always coarse. They are neyer pure and contain large amounts of disseminated clay. It is only near the Atlantic coast and near the Florida State line that

they are fine-grained, and even here there are some coarse-grained materials.

While in the foregoing the sands, clays, and sandstones are described separately they do not form stratigraphic units. Irregularly-bedded sands, clays, and sandstones may be seen in the same vertical section, the clays frequently being replaced by sands and vice versa. In places the sands and gritty clays may be seen to grade horizontally from non-indurated to indurated rocks, or from soft sands and clays into grits typical of the Altamaha formation.

Beds of gravel and conglomerate occur but form only a small proportion of the whole. They are interbedded with the clays, sands, and sandstones, and grade into them. Throughout the sands there are pebbles scattered promiscuously, or they may be arranged in lines a few inches thick. The conglomerates differ from the sandstones or grits only in the size of the rock particles. The beds of gravel and conglomerate are not persistent over large areas and are rarely more than eight or ten feet thick.

The pebbles making up the conglomerate are mainly quartz, quartzite, and feldspar. The quartz pebbles may be as much as three inches in diameter, and fragments of feldspar one and one-half inches in diameter have been observed. A feature of most of the gravels is the angularity or subangualrity of the pebbles.

The cementing materials of the conglomerates are clay and iron oxide. The material cementing the clays is probably opaline silica.

Brown iron oxide "pebbles" or nodules are in many places so abundant as to warrant special mention. Throughout the "wiregrass" region they occur in such quantity that the lands are termed "pebble" or "pimple" land in contrast to the lands covered by gray sand, and the "pebble" or "pimple" land is generally recognized as being superior in fertility. These nodules are a surface phenomenon produced by weathering; the iron oxide of the argillaceous sands is segregated into irregular, small bodies which are subsequently worn smooth. The "pebbles" vary in size from buckshot to eight or ten inches in diameter, but the buckshot size is most common. The mineral composing them is limonite or some closely allied iron mineral with clay and sand impurities. They are round or tubercular in shape, and have a slick or water-worn appearance, yet there is not much evidence of their having been transported by water and their smoothness may be due to attrition by raindrops. These pebbles were noted as being especially abundant at Stillmore, Fitzgerald, Douglas, Glenville, Pelham and Doerun.

Thickness.—The formation is variable in thickness; it is spread over an immense area and is, in a certain sense, a surficial deposit, being attenuated both to the northward and to the southward, and probably presenting the greatest thickness near the middle of the area in Georgia. The thickness, 350 feet or more, given by Veatch[1] in a previous paper is exaggerated for the recent investigations have demonstrated that underlying Oligocene clays, sands, and sandstones, penetrated in well borings to the depth indicated, were erroneously referred to the Altamaha (Lafayette?) formation. The maximum thickness can nowhere be observed in natural exposures and estimates must necessarily be made in part from well records. Observed and estimated thicknesses throughout the terrane are: Decatur County, not exceeding 50 to 75 feet; near Pelham, probably not greater than 100 feet; in southern parts of Grady, Thomas, Brooks, and Lowndes counties, absent, or not exceeding 40 or 50 feet; Waycross, 50 feet; Doctortown, 40 feet; Tilman Ferry Bluff, Altamaha River, 65 feet. Throughout the northern border, in Dooly, Pulaski, Dodge, Laurens, Johnson, Washington, Emanuel, Jenkins, and Burke counties, the thickness varies from six to eight feet to a thickness of probably 50 or 75 feet.

The maximum thickness certainly will not exceed 150 feet and the greatest thickness will be found in Laurens, Montgomery, Toombs, Coffee, Irwin, and Tift counties. It should be borne in mind that we are not always able to differentiate definitely the Alum Bluff and Altamaha formations and the figures given above are likely to be too great rather than too small, on acount of possible inclusion of Alum Bluff beds.

Paleontology and age.—Except for a few pieces of wood and fragments of oyster shells, the latter found in a gravel bed at Collins, and probably a mechanical mixture in the gravel, the typical Altamaha (Lafayette?) formation is devoid of fossils. There are, therefore, no paleontologic criteria for determining the age and stratigraphic position of the formation. Shells of probable Pliocene age occur in a deposit on Satilla River, six miles south of Atkinson, but the relation of the typical Altamaha formation to this deposit has not been conclusively determined. It is probable, however, that the Satilla River bed is contemporaneous with at least a part of the Altamaha (Lafayette ?) formation. Loughridge[2] described the Altamaha beds in part and referred them to the Miocene; Dall[3] in 1892 also referred the formation to the Miocene, but after the recogni-

[1]Science. n. s., vol. 27, January, 1908, pp. 71-74.
[2]Tenth Census, vol. 6, pt. 2, p. 16.
[3]Bull. U. S. Geol. Survey, No. 84, p. 81.

tion of the Oligocene in the Coastal Plain, referred it to the uppor Oligocene.[1] A part of the beds described by Dall are undoubtedly of upper Oligocene age.

The formation is younger than the Alum Bluff formation (Oligocene) which it overlies in bluffs of Altamaha, Oconee, Ocmulgee, and other rivers. In places on Altamaha and Savannah rivers deposits here provisionally referred to the Altamaha (Lafayette?) formation overlie unconformably beds correlated with the Duplin Miocene of North Carolina; of course, such beds are younger than Miocene strata upon which they rest. The formation is overlain in part by surficial gray sands of Pleistocene age. There seems, therefore, to be more grounds for referring it to the Pliocene or early Pleistocene than to any other series. The possibility of some of the beds here included in the Altamaha (Lafayette ?) formation being older, and some younger, has been discussed on a preceding page. It is probable that at least a part of the beds are the time equivalent of the so-called Lafayette formation.

Areal distribution.—The Altamaha (Lafayette ?) formation is the most widespread terrane in the Coastal Plain, covering in part an area of approximately 21,000 square miles, or three-fifths of the Coastal Plain area of the State. Its northern boundary is approximately marked by Waynesboro, Midville, Tennille, Dublin, Cochran, and Unadilla, and its western boundary is Flint River; thence a large part of the entire area south and east to Florida and the Atlantic Ocean is underlain by this formation. The most typical beds occur along Altamaha River and the formation underlies practically all the area known as the "wire-grass region." In the southern parts of Brooks, Thomas, and Grady counties, it is thin and partly removed by erosion. Near the coast deposits which may be remnants of the formation appear on the first marine terrace, (Satilla Plain), near Kingsland, Woodbine, and Pearl in Camden County and at a number of places near Savannah, Chatham County.

Physiographic expression.—The formation where it forms the surface produces a peculiar topography and a part of the area of its occurrence constitutes one of the major topographic divisions of the Georgia Coastal Plain, described in the first page of this report as the "Altamaha upland." This area is one of low hills with gentle slopes and softened outlines; of shallow, saucer-shaped valleys, often not more than 40 or 50 feet deep; of sluggish, clear-water streams,

[1]Eighteenth Ann. Pept., U. S. Geol. Survey, pt. 2, p. 340.

bordered by swamps and sand hammocks; of "bays" and cypress ponds.

Altamaha and Oconee rivers have cut deep valleys into the formation and precipitous bluffs are found along their courses and form an exception to the general type. The topography is in contrast to the broken, hilly areas of the Cretaceous and Eocene near the Fall Line; to the limesink topography to the west and southwest; and to the flat, sand-coated plains to the southeast.

Structure.—Inasmuch as the formation is not regularly bedded and there are no persistent layers, folding, faulting, etc., could hardly be detected even if they existed. Some inclination of beds from the horizontal was noted near Minter, Laurens County, but this was probably due to irregular deposition. A pecularity of the formation is the numerous local unconformities and abrupt horizontal changes in the character of the materials. The highest elevations are about 470 feet near Tennille and 450 feet at Ashburn, thence there is a gradual slope to the Atlantic coast, where the formation appears only a few feet above sea level.

Conditions of deposition.—The character of the deposits indicates a shallow water deposition, and affords evidences of conditions which find no parallel in the earlier Tertiary systems. The heterogeneous character of the deposits, the angularity and arkosic nature of much of the gravel, the rapidly shifting conditions of deposition, the numerous local unconformities and abrupt changes in the lithology, the absence of marine fossils and of any calcareous and glauconitic deposits, and other chemical and lithologic characteristics of marine sediments, precludes the classification of the Altamaha as a true marine deposit. The deposits are of terrestrial origin, produced as flood-plain and delta accumulations which, probably merged into littoral deposits.

At the beginning of the Pliocene there was an uplift of the Piedmont Plateau, a southward tilting, and consequent rejuvenation of the drainage. Great accumulations of detritus were dumped on a plain facing the sea, and coalescing deltas of coarse sediments rapidly accumulated and encroached upon the sea. The arkosic character of the sediments and general angularity of the pebbles indicate that this was a period of either great aridity or of extreme cold, in which disintegration predominated over decomposition. Much of the Altamaha has a true fluviatile or flood-plain aspect, while in some localities the presence of interstratified, fine-grained clay and sand suggests the presence of fresh-water lakes within the deltas. It is probable that the coarse delta deposits first laid down

were reworked and carried farther southward by streams. The source of the material was probably mainly from the Piedmont region, but there is evidence that the older Coastal Plain formations furnished a share of the detritus.

LOCAL DETAILS

The details concerning lithologic character, stratigraphic relations, etc., from which the general conclusions preceding were drawn, are given in the following sections and descriptions:

ALTAMAHA RIVER

The characteristic, lithologic features of the formation, its relation to the underlying Alum Bluff formation, and questionably, its relation to the Miocene, are exhibited in the bluff exposures on Altamaha River.

The sections exposed at Grays Landing, 11 miles below the Forks are:

Section at Upper Bluff, Grays Landing.

	Feet
Pleistocene ?	
7. At top, thin veneer of gray sand and gravel	
Pliocene ?	
Altamaha (Lafayette ?) formation.	
6. Characteristically mottled, argillaceous sand	8 to 15
5. Massive bed of gray, feldspathic sandstone or grit	15
Oligocene.	
Alum Bluff formation.	
4. Gray argillaceous sand	6
3. Interstratified sand and clay; clay layers a few inches thick; the sand has the appearance of the Alum Bluff sand in the southwestern part of the State	10
2. White, minutely jointly, fullers earth, contains round, siliceous concretions	2 to 12
1. Semi-indurated, greenish argillaceous sand	2

Section at Lower Bluff, Grays Landing.

Pleistocene ?	
9. Gray sand and gravel at the top, forms a thin veneer over the surface	
Pliocene ?	
Altamaha (Lafayette ?) formation.	
8. Mottled, argillaceous sand	8
7. Sandstone and gray sand	20
(Unconformity)	
Oligocene.	
Alum Bluff formation.	
6. Fullers earth-like clay and sand	6
5. Greenish argillaceous sand	5
4. Greenish clay	2
3. Massive sand, containing thin clay layers	6
2. White fullers earth	6
1. Greenish, rather compact sand	1

The massive Altamaha sandstone or grit also appears at Fall-in-Rock, 18-mile post, and at Piney Bluff, at the 20-mile post.

Section at Fall-in-Rock Bluff.

	Feet
3. At top, reddish sand	—
2. Massive bed of gray or greenish sandstone, forms a projecting ledge and a precipitous bluff	25
1. Greenish and gray clay and sand, softer than the above rock	10

It is probable that layer No. 2 belongs to the Altamaha formation; however, no unconformity appears between 1 and 2 and there are no fossils or other conclusive evidence of the age of the strata.

Section at Lower End of Piney Bluff.

	Feet
Pliocene ?	
Altamaha (Lafayette?) formation	
3. Abrupt bluff of greenish or gray, massive sandstone or grit	25
Oligocene.	
Alum Bluff formation.	
2. Compact, gray sand	3 (?)
1. Sandy, fullers earth-like clay; no fossils, but appears similar to the Alum Bluff deposits of southwestern Georgia	6

At Tillmans Ferry, 36 miles below the Forks, the entire bluff is made up of the Altamaha formation. The bluff is 65 feet high; the lower 35 feet is more or less indurated, and is a coarse feldspathic grit; the rock above is not well exposed and the upper slope is covered with sand and gravel and a few sandstone projections appear. The sandstone is conglomeratic in places and pebbles three-fourths of an inch in diameter were noted. Nothing resembling typical Alum Bluff materials appear.

Lower Sister Bluff, at the 49th mile-post, presents fine exposures. The lower, softer strata are carved into a "bad-lands" type of erosion and the bluff is the most picturesque on the river.

Section at Lower Sister Bluff

	Feet.
Pliocene ?	
Altamaha (Lafayette ?) formation	
7. Beginning at the top, mottled grit	10
6. Drab and greenish, friable aluminous sandstone	8
5. Coarse grained, pebbly grit	2½
(Unconformity.)	
Oligocene.	
Alum Bluff formation.	
4. Greenish, argillaceous sand, finer in texture than the above	8

		Feet.
3.	Drab, sandy clay	10
2.	White sand, thin clay layers	3
1.	Greenish and drab, compact, aluminous sand, finer in texture than No. 2. Laminated clay at the base	25

Proof that the strata in the upper and lower parts of the bluff are of different ages is not as patent as is desirable, for the beds exhibit no striking lithologic differences, and no fossils were found. However, at the upper bluffs, one mile above, there is better evidence of an unconformity.

The upper portions of the sections at Fort James (58th mile-post), have the characteristic appearance of the Altamaha formation but here again there is some uncertainty about the age of the beds.

Section at Upper Fort James Bluff

	Feet
Pliocene ?	
Altamaha (Lafayette ?) formation	
6. At top, pebbly mottled, argillaceous sand	30
5. Coarse, mottled grit	12
4. Greenish sandy clay	2½
3. Sandstone	6
2. Semi-indurated aluminous grit	4
(Unconformity)	
Oligocene.	
Alum Bluff formation.	
1. Greenish compact clay and sand mixture, perhaps finer in texture than the beds above	25

Section of Lower Fort James Bluff.

	Feet
Pliocene ?	
Altamaha (Lafayette ?) formation	
5. Beginning at the top, mottled sand not well exposed	30
4. Coarse, gray grit	12
3. Greenish or gray fine argillaceous sand, compact, massive	7
2. Sandstone or grit	2½
Oligocene	
Alum Bluff formation ?	
1. Fine-grained, greenish, argillaceous sand	20

At Oglethorpe Bluff (69th mile-post), the indurated phase of the Altamaha does not appear, and the formation is represented by vari-colored sand and by thin lenses of clay.

Section at Oglethorpe Bluff.

	Feet
Pliocene ?	
Altamaha (Lafayette ?) formation.	
6. Beginning at the top, red and yellow sand; contains some clay and is mottled in the upper part	18
5. Clay layer	2
4. Yellow and white crossbedded sand	25

		Feet.
	3. Purplish clay lens	5
	2. Coarse-grained, crossbedded, arkosic sand, feldspar and angular quartz gravel	20
	(Unconformity)	
Oligocene		
Alum Bluff formation ?		
	1. Greenish, compact argillaceous sand, no fossils	15 (max.)

Section at Linden Bluff, 73 Mile-post.

		Feet.
Pliocene ?		
Altamaha (Lafayette ?) formation		
	6. Mottled argillaceous sand (top of section)	12
	5. White, coarse, to very coarse sand with some gravel at the base	25
	(Unconformity)	
Miocene ?		
	4. White and yellow sandy clay	2
	3. Black silty clay	5
	2. Quartz pebbles in a matrix of bluish sandy clay	5
	(Unconformity.)	
Oligocene ?		
Alum Bluff formation ?		
	1. Greenish compact argillaceous sand	18

The beds which are marked questionably Miocene, occupy the same position in the section as the fossiliferous Miocene bed at the next bluff below,—Bugs Bluff. The lowest bed is referred to the Alum Bluff formation on the basis of the unconformity. Bugs Bluff is nearly a mile in length; the section given is at the lower end of the bluff, and is one mile by land from Doctortown.

Section at lower end of Bugs Bluff.

		Feet
Pleistocene		
	7. Gray sand, capping bluff	2
Pliocene ?		
Altamaha (Lafayette ?) formation ?		
	6. Mottled, argillaceous sand	10
	5. Coarse, white crossbedded sand, becomes coarser and pebbly at the base	28
Miocene		
Duplin marl		
	4. Faintly laminated, yellow and white sandy clay	5½
	3. Bluish mud	6½
	2. Shell and pebble conglomerate, contains *Pecten eboreus*, *Mytilus conradinus*	1½
	(Unconformity)	
Oligocene ?		
Alum Bluff formation ?		
	1. Greenish, compact, argillaceous sand	10

Section at Doctortown

	Feet.
Pliocene ?	
Altamaha formation ?	
6. Yellow and mottled argillaceous sand, has the typical surface aspect of the Altamaha	10
5. White and yelow crossbedded sand containing thin layers of small quartz pebbles	10
4. Red and yellow sand containing thin clay laminae	10
Miocene.	
Duplin marl	
3. Calcareous fossiliferous sand or sandy friable marl	1
2. Bluish sand containing the Miocene fossils, *Pecten eboreus*, *Mactra congesta*	4
(Unconformity)	
Oligocene ?	
Alum Bluff formation ?	
1. Coarse, bluish or greenish compact clayey sand to water's edge	7

The Sansavilla bluffs, 27 and 28½ miles, respectively, below Doctortown, are the last high bluffs on the river. Paleontologic evidence of the age of the beds is lacking; the succession of beds is similar to that at Doctortown and Bugs Bluff.

Section at Upper Sansavilla Bluff

	Feet.
Pleistocene	
Okefenokee formation	
3. Fine, brown and white quartz sand, covering a terrace plain	
Pliocene ?	
Altamaha formation ?	
2. Bluish-gray sand, interstatified with white, thinly laminated clay; the clay layers contain small bits of plant remains	30
Miocene or Oligocene ?	
1. Bluish, compact, argillaceous sand	5(?)

Section at Lower Sansavilla Bluff.

	Feet.
Pleistocene.	
Okefenokee formation.	
8. Fine brown and white, incoherent quartz sand .	10
Pliocene ?	
Altamaha formation ?	
7. White clayey sand	
6. White clay layer, fine-grained thinly laminated clay	
5. Sand	18
4. Thin clay layer	
3. Argillaceous sand	
2. Clay, fullers earth-like	
Miocene or Oligocene ?	
1. Coarse, crossbedded compact, argillaceous sand .	8

EAST AND NORTH OF ALTAMAHA RIVER

On the Macon, Dublin, and Savannah Railroad, between Vidalia and Dublin, various lithologic phases appear in the cuts. The formation near the surface is an orange yellow loam, beneath which is a mottled, argillaceous sand splotched with red, yellow, white, and purple. Crossbedded sands and local beds of gravel appear, and at a number of places are drab claystones and gray, aluminous sandstones. The formation is uniformly overlain by a gray, incoherent sand, from two to six feet thick.

A bed of coarse gravel consisting of pebbles and cobbles was noted in a railroad cut on the east side of Ohoopee River, two miles east of Adrian.

Section in railroad cut two miles east of Adrian.

Altamaha formation	Feet
4. Gray, incoherent sand	5
3. Yellow, argillaceous sand	3
2. Gravel bed, maximum thickness	2.5
1. Coarse, gritty clay and argillaceous sandstone, typical Altamaha	12

The gravel bed is not a persistent layer and soon thins out, proving that it is merely a lens in the Altamaha (Lafayette ?) formation. The pebbles are mostly quartz, but a few pebbles of decomposed feldspar and vitreous flint, which has the appearnce of Vicksburg flint, occur; unlike most of the Altamaha gravel the pebbles are smooth, well rounded, and of large size, some three or four inches in their longest diameter. The lower bed contains coarse fragments of crystalline quartz in which flakes of mica occasionally occur. This is evidence that the detritus was derived directly from the Piedmont Plain.

Characteristic phases of the Altamaha formation occur at Stillmore, Emanuel County. The surface is covered with small, brown, iron oxide concretions about the size of buckshot, and the weathered part of the formation presents a mottled or "calico" appearance. The best exposure appears in the deep cut of the Central of Georgia Railway within the town limits.

Section at Stillmore.

Altamaha formation?	Feet
7. Gray sand residual	2½
6. Yellow loam, presenting a mottled or "calico" appearance	6
5. Yellow and drab clay layer	2
4. Mottled purplish and gray argillaceous sand	3
3. Greenish sand, containing a small amount of clay	3½
2. Drab, "stickey", sandy clay	3½
1. Aluminous grit or sandstone	2

At Ohoopee station, Toombs County, there is a cut about 25 feet deep in which the sands and clay beds exhibit local unconformities.

On the south side of Pendleton's Creek, two miles south of Ohoopee, there is a rough, craggy bluff of Altamaha sandstone, 15 feet high. The rock is made up principally of sharp quartz sand and a small amount of disseminated clay, and is similar to the sandstone at other localities. No fossils occur.

At the Jack Williams cut, four miles west of Collins, typical clay and aluminous grit are exposed.

In a cut of the Seaboard Air Line Railway three-quarters of a mile west of the station at Collins, Tattnall County, purplish sand and gravel layers are overlain by orange-colored, sandy loam. The locality is of interest since fragments of oyster shells, which could not be specifically identified, were found in a gravel layer 10 feet from the top of the cut. These shells may have been transported with the gravel. This is the only locality in this formation where fossil animal remains have been found. The pebbles are small, not exceeding an inch in length or diameter, angular or subangular, and consist principally of quartz with a small percentage of decomposed feldspar.

Grits and claystones, similar to those described above, outcrop on the farm of Dr. Donaldson, on Lott Creek, one mile northeast of Register. There is a rugged bluff 10 feet high; the rock is fine-grained, and the cementing substance is opaline silica; parts of the sandstone are quartzitic, as at some other localties, although this is not a charactertistic phase. It can not always be certainly determined whether such materials belong to the Altamaha (Lafayette ?) formation or to the Alum Bluff formation.

At Ludowici, Liberty County, coarse, mottled sands with thin layers of clay appear in a cut at the factory of the Ludowici Roofing Tile Company. These sands and clays resemble the materials of the Altamaha (Lafayette ?) formation.

Red sands resembling Altamaha materials were noted beneath the Pleistocene gray sands between Darien Junction and Ludowici, and also beneath the gray sands between Darien Junction and Darien.

At Waynesboro and Greens Cut, Burke County, the formation appears in railroad cuts. It consists of mottled, argillaceous sands and loams, easily distinguishable from the red sands of the Claiborne group which it overlies.

A good exposure appears in a railroad cut three miles north of Munnerlyn, Burke County.

Section in railroad cut, three miles north of Munnerlyn.

Altamaha formation	Feet.
3. Mottled sand, and drab, massive clay, oxidized red	10
2. Coarse-grained sandstone or grit	5
1. Bluish-gray clay containing coarse grains of quartz and feldspar	10

The clay is slick and unctuous, has a high air shrinkage, and when dry crumbles into very hard lumps. Similar clay occurs near Screven approximately 100 miles to the southward.

On the L. L. Brasselle place, six miles south of Midville, bluish or drab claystone, and sandstones or grits, appear in a rather pictureqne bluff about 12 feet high. At a lower level a white quartzitic sand bears poorly preserved fossils, and oyster shells embedded in a white, calcareous sand have been thrown from a nearby well. The fossil-bearing beds undoubtedly belong to the Alum Bluff formation. The claystones or grits observed at this locality probably belongs to the Altamaha formation. They contain no fossils. There are no exposures showing the two phases in contact.

Sandstones and gritty claystones appear at Parramore Hill.

Section in railroad cut north of Parramore Hill Station

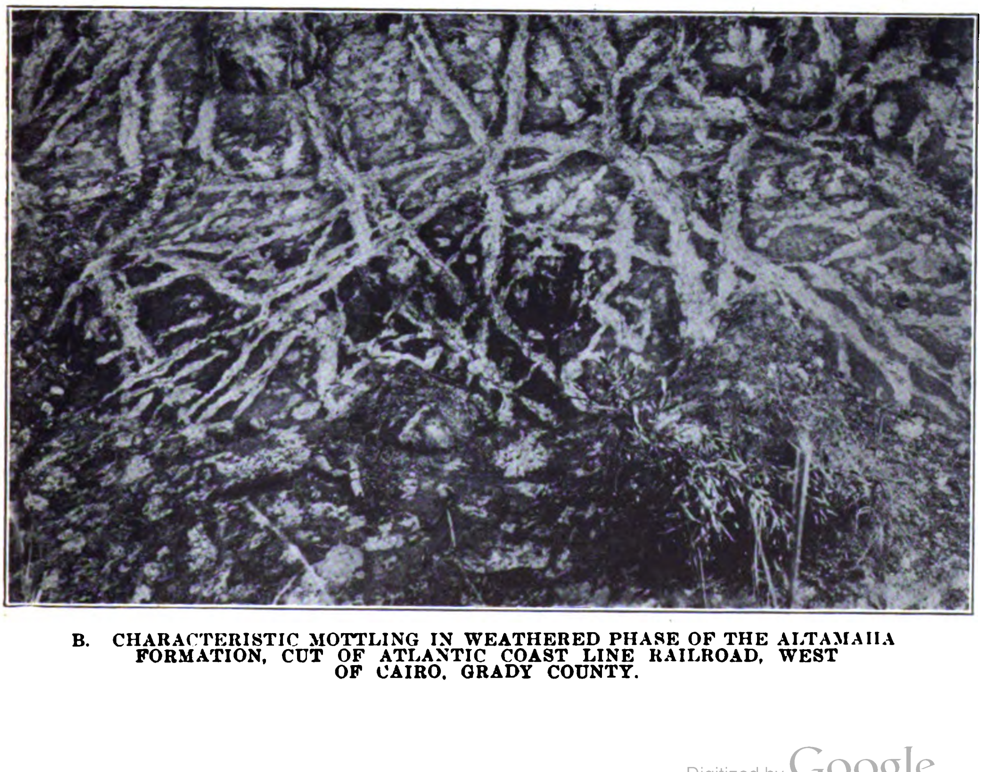
Altamaha formation	Feet.
4. Weathered red and yellow, sandy clay	4
3. Gray, coarse-grained sandstone	2
2. Drab or chocolate-colored, semi-indurated clay . .	3
1. Very hard, massive, drab clay	7

The sandstone is a local induration and not a persistent layer. Coarse, quartz grains are embedded in the fine-grained ground-mass of the clay. There is no evidence of any overlying formation except a thin veneer of sand.

Mottled, argillaceous sands, tentatively referred to the Altamaha (Lafayette ?) formation, overlie Miocene strata at Porters Landing, Trowel Landing, and at Sisters Ferry on Savannah River, and similar materials appear in cuts of the Seaboard Air Line Railway three miles north of Clyo in Effingham County. At Ebenezer Church, 30 miles above Savannah in Effingham County, a small thickness of red sand with thin, laminated clay layers overlie Miocene beds at an elevation of about 40 feet above the river; these are probably of the same age as the other Savannah River occurrences just noted. These deposits may all prove to be Pleistocene terrace deposits.

North of Savannah, along the Seaboard Air Line Railway, red sands appear at a few places beneath the gray surface sand, and are similar in litholoigic appearance to the red, argillaceous sands of Effingham County.

A. CUT OF ATLANTIC COAST LINE RAILROAD WEST OF CLIMAX, DECATUR COUNTY, SHOWING STRATA OF THE ALTAMAHA FORMATION.



B. CHARACTERISTIC MOTTLING IN WEATHERED PHASE OF THE ALTAMAHA FORMATION, CUT OF ATLANTIC COAST LINE RAILROAD, WEST OF CAIRO, GRADY COUNTY.

In the vicinity of Savannah red sands containing thin clay laminae and sandy beds appear at a number of localities and may represent the Altamaha formation. The difficulty of correlating these deposits with the Altamaha, however, is at once apparent, since they are unfossiliferous and only widely separated exposures occur. They are older than the gray sands which veneer the first marine terrace, and older than the Pleistocene muds which also occur in basins on this terrace. The red sands ,themselves, however, may be of Pleistocene age. Exposures of these materials were noted in cuts of the Montgomery branch of the Seaboard Air Line Railway, three, four, and nine miles west of Savannah, and in cuts of the Jacksonville branch of the same system one-third of a mile south of Florida Junction, all in Chatham County.

Along the Seaboard Air Line Railway, between Savannah and Altamaha River, red sands and mottled, sandy clays, probably corresponding to the deposits noted in the vicinity of Savannah, occur at Burroughs, Limerick, and Arcadia.

WEST OF ALTAMAHA AND OCONEE RIVER

At Kramer, five miles west of Abbeville, Wilcox County, the formation has an arkosic character. Feldspar pebbles an inch in length were noted in a conglomerate which appears in the railroad cut, one-half mile west of the station. The rock is composed of quartz, feldspar, mica in minute flakes, and small grains of a black mineral, probably ilmenite; these minerals are in a matrix of white clay, and silica is the cementing agent. The quartz varies from small grains to angular pebbles an inch in length. Some of the feldspar is but little decomposed. Such large fragments of feldspar this distance from the Fall Line are of unusual interest and are not found in any of the older Coastal Plain formations.

At Fitzgerald, Ben Hill County, the Altamaha (Lafayette?) formation appears at the surface as an argillaceous, massive sand, mottled red and white, covered by gray, incoherent sand. Brown, iron oxide "pebbles" are abundant and vary from the size of buckshot to three or four inches in diameter. They are evidently derived from the Altamaha formation by weathering but have subsequently been worked into the gray surface sands which overlies the Altamaha. Loose beds of these pebbles were noted in the gray sands along the Atlanta, Birmingham, and Atlantic Railroad track west of Fitzgerad, near the railroad shops.

Outcrops of indurated Altamaha sandstone and claystone occur a short distance north of Fitzgerald on the Bowens Mill road.

In a cut of the Southern Railway, one mile north of Helena, Tel-

fair County, the lens structure of the clay beds and the characteristic, coarse, gritty texture of the formation are exhibited.

Large, brown, iron oxide accretions, 8 or 10 inches in diameter, irregularly rounded, occur at the surface in the vicinity of Broxton and Douglas, Coffee County.

At "the Rocks" nine miles northeast of Broxton, there is 20 feet of fine-grained, aluminous sandstone and claystone exposed in a narrow, rugged ravine. The rock bears no fossils, and its stratigraphic position is determined entirely by its lithologic resemblance to indurated phases of the Altamaha at other localities.

An excellent exposure of feldspathic grit or sandstone occurs at the 339th milepost on the Southern Railway, two miles northeast of Hazelhurst, Jeff Davis County. There is 10 feet of rock exposed; a short distance south of the rock exposure, the rock retains its texture and composition, but is not indurated, suggesting that the sandstones of the Altamaha are local indurations only and not continuous beds.

The Altamaha (Lafayette ?) formation appears in the railroad cuts at Jesup, Wayne County, but is largely obscured in this part of the State by a thin covering of gray sand. In a cut of the Southern Railway, three miles southeast of Jesup, the exposure has the lithologic appearance of the Altamaha, but may be an Okefenokee Pleistocene deposit. The formation here contains coarse gravel and large chunks of silicified wood. In the clay pits of the brick-yard at Odessa the formation consists of alternating layers of fine-grained, plastic clay and ferruginous quartz sand. Neither the clay nor sand layers are persistent, and the two intergrade and replace each other. Some of the sand is very coarse, being made up of angular quartz fragments as large as peas.

Characteristic, lithologic features and structure again appear in the cuts two to two and one-half miles south of Screven, Wayne County. Coarse, gritty clay similar in appearance to that at Munnerlyn, Stillmore, Helena, and other localities north and west is exposed. No exposures of the underlying older Tertiary formations appear.

Characteristic Altamaha clays and sands appear in a cut one mile northeast of Blackshear, Pierce County, the weathered surface phase of which is a mottled, argillaceous loam; there are local unconformities between sand and clay beds, and the sand is coarse in texture and angular. The sands and clays are similar in composition to the sandstones and claystones of the formation to the north and west, differing only in being unconsolidated.

Characteristic Altamaha materials appear in the numerous railroad and road cuts in the vicinity of Waycross, Ware County. The

most instructive exposure is in a cut of the Atlantic Coast Line Railroad, two miles north of Waycross. Here are revealed peculari-ties of deposition, local unconformities, and the relation of the mottled, argillaceous sands to the less altered parts of the formation, and to the gray sands which cover the plain.

Somewhat similar sands and clays appear in Red Bluff on the right bank of Satilla River, four miles east of Raybon, Wayne County, and about eight miles above the King Plantation bluff. No fossils were found.

Section at Red Bluff

	Feet
4. At top, light yellow, incoherent sand (Pleistocene)	3
Altamaha (Lafayette ?)	
3. Mottled sand containing a small amount of disseminated clay	10
2. White, red, and yellow, fine sand	15
1. Gray, very sandy clay	4

The only means of establishing the correspondence in age of these beds with the typical Altamaha farther west, is by tracing the beds; this is hindered by the gray sand covering and the lack of continuous exposures.

Sands and clays similar to those exposed in a cut three miles south-east of Jesup occur at the brickyard at Waynesville, Wayne County.

A locality of much interest in connection with the discussion of the Altamaha formation is the bluff on Satilla River at the King plantation, six miles south of Atkinson, for fossils occur in the basal bed of the section and there is some probability that the beds are contemporaneous with the Altamaha beds exposed at Waycross and Blackshear, about 25 miles to the westward.

Section at King Plantation

	Feet
9. Gray sand (Pleistocene)	1
Pliocene	
8. Bluish, sandy clay, laminated; red splotches due to weathering	4
7. Gray, sharp sand; a small amount of disseminated clay, some small quartz pebbles	8
6. Drab clay layer	2
5. Gray sand, containing clay laminae an inch or two thick	8
4. Gray, fine-grained, very sandy clay	3
3. Gray sand	2
2. Yellow sand, fragile molds of shells	2
1. Bluish, laminated argillaceous sand, containing fragile shells and a few small bone fragments	2

From the shell bed No. 1 Mr. T. H. Aldrich identified several species and regards the horizon as probably Pliocene.

Fossils from bluff of Satilla River, King Plantation, six miles south of Atkinson, identified by T. H. Aldrich.[1]

Rangia cuneata (Gray)	Modiolaria sp?
Mulinia lateralis (Say)	Gemma purpurea, H. C. Lea
Mulinia congesta (Conrad)	Neretina sp?
Dosinia sp?	Neverita sp?

New Species

Potamides saltillensis	Amnicola georgiensis
Potamides cancelloides	Amnicola expansilabris
Paludestrina plana	Planorbis antiquatus
Amnicola saltillensis	

There is no good evidence of an unconformity between the fossiliferous bed and the upper part of the bluff. Although no definite, structural break was detected in the section there is some ground for believing that a part of the section above the fossiliferous layer, in addition to the surface gray sand, should be referred to the Pleistocene and not to the Pliocene.

On the Jacksonville branch of the Seaboard Air Line Railway at Waverly, Woodbine, Colesburg, and Kingsland, in Camden County, red sands, which are probably of the same age as the red sands in the vicinity of Savannah are exposed in the shallow cuts. Although resembling the Altamaha materials, and here tentatively referred to that formation, they may eventually prove to be Pleistocene terrace deposits. These red sands are covered with a thin mantle of surficial, gray sands.

WESTERN AND SOUTHERN LOCALITIES

Drab claystones and gray sandstones appear near the Georgia Southern and Florida Railroad, one-half mile north of Worth, Turner County.

Section one-half mile north of Worth.

	Feet.
Altamaha (Lafayette ?) formation.	
6. Upper part of hill partly concealed, projecting beds of sandstone and conglomerate	20
5. Drab, sandy claystone, massive	20
4. Mottled clay layer	1.5
3. Gray sandstone or grit in places very hard	5
2. Mottled clay	5
1. Indurated gray or drab, fine textured clay; breaks with an angular, conchoidal fracture	8

At this locality indurated sands and clays may be seen grading into non-indurated materials which have the mottled aspect so characteristic near the surface throughout the Altamaha terrane.

[1]Nautilus, vol. 24, No. 11, March, 1911, p. 131.

In a cut of the Atlantic Coast Line Railroad near the bridge, one-half mile east of Sylvester, Worth County, the following section was observed:

Section in railroad cut one-half mile east of Sylvester.

	Feet.	In.
Altamaha (Lafayette?) formation		
7. At the top of the cut, orange-colored loam containing small, iron oxide "pebbles"	3	
6. Yellow, crossbedded sand containing small angular quartz pebbles; thin layers of clay in the sand	6	
5. Purple sand	0	3
4. Yellow sand	7	
3. Purple sand	0	4
2. Yellow sand	0	6
(Unconformity.)		
1. Purplish, sandy, massive bed of clay	2	6

The characteristics displayed here are angular, lath-shaped, quartz pebbles and unconsolidated sands.

In the vicinity of Ticknor and Doerun, Colquitt County, there are areas of typical "pimple" or "pebble" land, or land strewn with small, brown, iron oxide concretions resutling from the weathering of Altamaha materials.

Pelham, Mitchell County, is located on the top of the Altamaha escarpment which parallels Flint River. Near the surface there is a red or mottled, argillaceous loam overlain by a carpet of gray sand. Drab and purplish, very sandy clays occur beneath the surface formation. "Pimple" land occurs in this neighborhood also.

At Forest Falls, or Limesink, eight miles north of Whigham, Grady County, the Altamaha (Lafayette ?) formation varies in thickness from 8 to 20 feet. It overlies the Alum Bluff formation unconformably. At the base are gray and yellow sands and greenish, "gummy" clays, and at the surface red, case-hardened sands.

In southern Georgia and near the Florida line the formation has a lesser thickness, and over parts of Grady, Thomas, and Brooks counties is entirely absent. The topography of this part of the State has been influenced more by the Alum Bluff formation than by the Altamaha (Lafayette ?) formation. Sandstones and conglomerates which farther to the northward characterize the Altamaha terrane, are here absent.

In the railroad cuts and in an adjacent gully three-quarters of a mile west of Climax, Decatur County, the Altamaha formation overlies gray, or greenish and drab, interstratified clays and sands which probably belong to the Alum Bluff formation. Neither the upper nor lower exposures bear fossils, and there are differences

of opinion as to a division of the strata. A detailed section at this locality, made by Dr. Vaughan, has been quoted on page 348. All the beds exposed from the level of the track up, except the gray, surficial sands, in the second cut west of Climax have the lithologic characters of the Altamaha formation at other localities.

The section in the second cut, not including the gully exposures, is as follows:

Section in railroad cut three-quarters of a mile west of Climax.

	Feet.
Altamaha (Lafayette ?) formation.	
6. Beginning at the top,—gray incoherent sand reaching a maximum of	3
5. White and orange-colored, argillaceous sand, mottled and massive, due to weathering	7
4. Thin, siliceous crusts of limonite, apparently marking an unconformity	1
3. Purplish, white and yellow, crossbedded sand . . .	15
2. Gray or drab clay layer with purplish splotches; appears to be a lens in the sand; varies from 6 to 12 feet above the level of the track . . .	2.5 to 4
1. White, purplish, and yellow, crossbedded, coarse sand; very small percentage of disseminated clay; sand mainly angular, quartz grains; maximum thickness	12

The beds between the level of the branch and the track level, about 40 feet, probably belong to the Alum Bluff formation.

Characteristic, mottled, argillaceous sands of the Altamaha formation appear in the Atlantic Coast Line Railroad cuts near Fowltown and Recovery in Decatur County. In a cut one and one-half miles west of Recovery the contact with Alum Bluff is exposed. Six feet of mottled, argillaceous sand rest unconformably upon two to four feet of fine, gray sand containing a small amount of disseminated clay. About 10 feet below the level of the track a sandy limestone referable to the Chattahoochee formation is exposed.

In the first cut east of the station at Whigham, Grady County, the Altamaha formation appears as thin layers of red and purple sand, alternating with laminated clay. Some of the clay laminae are not more than a fraction of an inch in thickness, and the clay layers have sand partings. In a cut one mile east, light, green clays of the Alum Bluff formation appear overlain by orange-colored sand of the Altamaha formation.

Fine exposures appear in the railroad cuts at Cairo, Grady County. The formation here consists of mottled, sandy clays and crossbedded, yellow and red sands, with dull yellow loam at the surface. The peculiar mottling or calico effect, due to weathering, is shown in a photograph made in a cut west of Cairo. Plate XXVIII-B.

The Alum Bluff formation is exposed in the terrace escarpments of Ocklockonee River at the 204th and 205th mileposts on the Savannah-Montgomery division of the Atlantic Coast Line Railroad. The overlying Altamaha (Lafayette ?) formation appears in a cut which extends from milepost 203 eastward for one-half mile; the formation here is a massive, argillaceous sand, mottled with yellow and gray. At Thomasville, Thomas County, the Altamaha is represented by a small thickness of red sand.

South of Cairo, Thomasville, Boston, and Quitman, the formation appears only on the higher hills as a capping. It consists mainly of red loam and may be easily confused with the red, argillaceous sand, residual from the Alum Bluff. North of these points the formation presents topographic and lithologic characters similar to those which prevail in the northern part of the Altamaha area.

One of the few exposures south of Thomasville which are considered referable to the Altamaha, occurs on the Tallahassee road, 12 miles south of Thomasville.

Section twelve miles south of Thomasville.

	Feet.
5. At top of hill—gray, surficial sand	2
Altamaha (Lafayette ?) formation.	
4. Stratified sand and clay, mottled red and white, coarser in texture than the underlying materials	20
Alum Bluff formation (contact obscured by weathering and creep.)	
3. Residual, red, sandy clay	30
2. Greenish, fossiliferous clay	10
Chattahoochee formation.	
1. Limestone	15

The materials capping the hill on the Mallet plantation on the Boston-Monticello road, four and one-half miles southwest of Boston, Thomas County, have much the appearance of the Altamaha formation, but their relation to the underlying residual sand of the Alum Bluff formation is obscure.

The Altamaha formation appears in railroad cuts near Quitman, Brooks County, and near Kinderlou and Valdosta, Lowndes County. It attains only a small thickness and is underlain by sandy clays of the Alum Bluff formation.

East and southeast of Valdosta the country is a flat, sand-covered plain in which there are few natural exposures. Yellowish, mottled sands occur beneath the gray surface sands. It is probable that there is a small thickness of the Altamaha formation underlying this region. The mottled sand in the cut one mile west of Stockton has the appearance of this formation.

PLEISTOCENE

The Pleistocene deposits consist of thin, fluviatile and marine terrace accumulations of sand, clay, and gravel. The only systematic description of the Pleistocene of the Georgia Coastal Plain previously given is that of W J McGee.[1] McGee first studied the Pleistocene in the District of Columbia, gave it the name "Columbia formation" and differentiated it into three phases, the fluvial, interfluvial, and low-level phases. The formation was traced southward to the Mississippi and to Mexico. He recognized the three phases in Georgia and gave brief, general descriptions of them. Previous to McGee's studies, Lyell had already observed successive terraces on the coast of Georgia, and other observers have also mentioned them, but their geological significance seems not to have been fully presented.

In the present report the differentiation is based largely upon physiography, and the formations are described in greater detail than in McGee's report. The name Columbia as a group name is retained. The divisions are given in the following table:

Pleistocene	Columbia group	Satilla formation	Marine terrace deposits
			Fluviatile deposits
		Okefenokee formation	Coastal terrace sand
			Fluviatile deposits

The solution of the Pleistocene problem of Georgia, and in fact of the Atlantic Coast region in general, is conditioned largely upon a knowledge of topographic details. This knowledge can not be acquired until detailed topographic maps have been made available.

In Georgia the Pleistocene formations do not lie superimposed one upon the other, but occupy terrace benches at different topographic positions with respect to each other.

During the Okefenokee period gray sands and other sediments were laid down on a terrace plain of probable marine origin, now 60 to 125 feet above sea-level, and contemporaneous fluviatile terrace deposits consisting of gravels, sands, and loams, were laid down on the "second" terrace skirting the larger rivers.

During the Satilla period gray sands and muds were laid down on a marine terrace, a flat plain 20 to 40 miles broad, bordering the coast at elevations of 15 to 40 feet above sea level, and corresponding terrace alluvium was deposited along the rivers.

Although the available data are at present too incomplete to admit of a positive statement it is not improbable that an older Pleistocene

[1]The Lafayette formation; Twelfth Ann. Rept. U. S. Geol. Survey, pt. 1, 1890-1891, pp. 353-521.

terrace plain exists to the westward of, and at a higher elevation than the Okefenokee terrace. Evidence of such a plain is to be seen in the topographic aspect of the country lying along the Atlantic Coast Line Railroad between Valdosta, Lowndes County, and Waycross, Ware County; along the Atlantic Coast Line Railroad between Pearson, Coffee County, and Waycross; and along the Southern Railway between Baxley in Appling County, to near Jesup, Wayne County. The general surface of the belt of country crossed by these railroads is a nearly level plain which gradually descends towards the coast. Along the first mentioned railroad there is a descent from an elevation of 215 feet at Valdosta to 140 feet at Waycross; along the second there is a descent from 205 feet at Pearson to 140 feet at Waycross; and along the third, a descent from 206 feet at Baxley to 155 feet at Odum.

The northern part of Effingham and the southern parts of Screven and Bulloch counties, also present the aspect of a plain similar to the Okefenokee Plain.

COLUMBIA GROUP

OKEFENOKEE FORMATION

The name Okefenokee is derived from Okefenokee Swamp, a great, swampy tract in southern Georgia covering parts of Charlton, Ware and Clinch counties. The swamp occupies a portion of the plain on which were laid down the deposits under consideration. The Okefenokee formation consists in part of coastal terrace deposits and in part of river terrace or fluviatile deposits. During this period there was probably a depression of the land, the coast line perhaps being 40 to 75 miles west of its present position. Coastal sands and probably other sediments were laid down forming a terrace, and contemporaneous fluviatile deposits were formed on terraces skirting the larger rivers as far as the Fall Line. The coastal terrace formed during this period is a flat plain 20 to 40 miles wide, which varies in elevation from 60 to about 125 feet above sea-level. It is covered with gray and white quartz sand. The river terraces lie 50 to 100 feet above zero water level, and form prominent topographic features along Savannah, Ocmulgee, and Chattahoochee rivers. The terrace deposits consist of sands and gravels of fluviatile or fluvioestuarine origin. The two types of deposits will be described separately.

COASTAL TERRACE DEPOSITS

The coastal terrace phase of the formation is represented principally by a thin deposit of gray sand which covers the Okefenokee Plain, a topographic division which has been described in the chapter

on physiography. The age of the formation is determined by the physiographic position and not by the evidence of fossils since fossils are entirely absent. The western boundary of this plain is marked approximately by a line extnding from near Sisters Ferry on Savannah River, or Clyo, southeastward through the northern part of Bryan County, to about 10 miles north of Ludowici, Liberty County; thence to Jesup, and along the Atlantic Coast Line Railroad to near Waycross, Ware County; and thence to the western boundary of the Okefenokee Swamp. It includes the Okefenokee Swamp, and the towns of Folkston, Jesup, Ludowici, and Hinesville are situated upon it. Its eastern boundary is marked by an escarpment 20 to 40 miles from the coast, which separates it from the first or Satilla terrace. (The approximate area of this plain is shown on the sketch map, Fig. 1, p. 28).

The most conspicuous deposit on the plain referable to this period is a gray sand. Red and yellow sands containing thin clay layers and pebble beds underlie the surface sand and are doubtless in part Pleistocene, although in this report such materials are in most cases tentatively referred to the Altamaha formation. The Okefenokee formation is not in contact with any formation older than Pliocene and Miocene. On the west the sand of the Okefenokee Plain merges into the surficial sand of a higher plain and it is not always possible to draw a sharp line of demarkation between them. Swampy flats traversed by small creeks occur in the plain and probably the muds underlying these flats belong to this period of the Pleistocene.

The gray surface sand is composed almost entirely of subangular quartz particles, probably derived from the older Coastal Plain formations. On the whole, it is, perhaps, finer in texture and lighter in color than the upland sands to the west. At the surface the sand is loose, incoherent, and structureless, but shows faint lines of stratification and current bedding at depths. At a few localities it is white at the surface and darker-colored beneath, the white phase having been formed by leaching and not as a separate deposit. A notable occurrence of white sand lies along the railroad between Ludowici and Darien Junction.

In the Okefenokee Swamp the only deposits known, aside from the recent peaty accumulations, are white, yellow, brown, and black sands,—the dark colors being due to large amounts of organic matter. The sand is in places indurated, due probably to a cement of iron oxide. This is the so-called "hard pan" of this area.

The thickness of the sand is small, probably averaging less than 10 feet over the whole plain. Good exposures appear at Folkston, where the average thickness is six or eight feet, with local accumula-

tions reaching 15 or 20 feet; the sand is gray, almost white at the surface, and light yellow beneath. At other places over the plain the thickness varies from two or three to 10 or 15 feet.

The plain which the Okefenokee sand covers is in general flat and almost featureless. Some of the larger streams which traverse it have bluffs 30 or 40 feet high, but these are exceptional. The erosive power of rainwater is lessened by the porous sand, and ravines and gullies are rare. The main streams have few tributaries. The plain is dotted with cypress ponds and swamps due to original inequalities in the land surface. Locally the sand has been heaped into low ridges and hills which in certain instances were controlling factors in determining the courses of streams. The anomalous course of St. Marys River is probably due to obstructing sand ridges.

As may be inferred from the lithologic description given above, little can be said regarding the structure of this formation. It conforms to the low seaward slope of the Okefenokee Plain and varies in elevation from 60 to 125 feet above sea-level.

LOCAL DETAILS

Surficial sands.—Gray, yellow, and brownish to almost black sand, reaching a thickness of 20 feet or more, occurs in and on the borders of Okefenokee Swamp.

The sands are prominent at Folkston; at the surface they are gray, or in places almost white, becoming yellow at depths. A high, sand-covered scarp occurs a short distance east of Folkston and borders St. Marys and Satilla rivers on the west. Fine-grained, sandy clay or mud, which may be an Okefenokee Pleistocene deposit, underlies a broad flat through which Spanish Creek flows.

East of Waycross, near the 42d mile-post on the Atlantic Coast Line Railroad, cuts on either side of Big Creek expose 10 or 15 feet of brownish sand showing stratification lines. The color is due to organic matter.

Heavy beds of gray sand occur at Waynesville, Wayne County, which is on the scarp between the first and second Pleistocene terraces. A considerable area in southeastern Wayne County and eastern Pierce County forms a flat, swampy, palmetto and pine covered plain, over which the gray sands have a thickness of only three or four feet.

Gray sands are conspicuous on the eastern edge of the plain at Mount Pleasant in Wayne County, and similar sands occur between Jesup and Altamaha River in the same county. At Ludowici, Liberty County, the sands covering the plain are gray to almost white, and of small thickness. This pine-clad sand plain seems to

merge gradually to the northwestward into the dry, rolling, wiregrass, sandhill region covered with a scattered tree growth, which surrounds Glenville, in Tattnall County. Gray sands are conspicuous on the eastern edge of the plain at Walthourville in the same county.

The sand-covered Okefenokee Plain extends northeastward from Ludowici, through Bryan and Effingham counties, to Savannah River. In Bryan County the surface gray sands and the typical topography of the plain are finely exhibited along the Seaboard Air Line Railway between Ellabell and Groveland. Here the western limit of the plain is on the west side of Cannoochee River, between Groveland and Daisy.

Deposits beneath the surficial sands.—At numerous places within the area covered by this plain there are, beneath the surface sands, deposits of sand and clay the ages of which are more or less problematic. Some of these deposits probably belong to the Okefenokee formation. Occurrences of such materials, concerning the Pleistocene age of which but little doubt exists, are described or referred to below.

The sands and clays overlying the Charlton formation in the higher bluffs on St. Marys River, described on pages 392-400 of this report, are tentatively referred to this formation.

In a cut on the Southern Railway, three miles east of Jesup, a coarse, quartz gravel bed, which may belong to this division of the Pleistocene, is exposed.

Sands and clays, probably referable to the Okefenokee formation, underly the surface sands at brickyards near Waynesville and Odessa, Wayne County. Unconformities, the significance of which could not be determined appear in these sections and it may be that both the Okefenokee and Altamaha formations are represented.

Red and gray, argillaceous sands probably belonging to the Okefenokee formation, appear in bluffs of Savannah River at Frying Pan Landing, Gaffney Landing, and at Ebenezer, Effingham County.

Certain deposits, described in the chapter on the Altamaha formation and tentatively referred to that terrane, may eventually prove to be of Pleistocene age and referable to this formation.

FLUVIATILE TERRACE DEPOSITS

Bordering the large rivers of the Coastal Plain of Georgia are remnants of a plain, higher than the "second bottoms" or Satilla Plain, and 50 to 200 feet lower than the general upland of the region. It is believed that the deposits laid down on this plain are

contemporaneous with the Okefenokee coastal deposits. While the coastal portion of the Okefenokee terrace plain was being cut and the gray sands and other deposits were being laid down upon it, the terraces bordering the present river valleys, and their accompanying deposits, were being formed,—either by the waves along the borders of reentrant estuaries, or by the meandering of the rivers in the parts of the valleys not submerged. The river terraces coalesce with the coastal terrace.

The river terrace plains lie 50 to 125 feet above the present rivers. Immediately subsequent to their formation the fluviatile portions of the Okefenokee plain filled the valleys from side to side, having widths varying from one to ten miles; into these ancient plains the rivers have intrenched themselves, forming younger plains at two lower levels,—one the Satilla plain, and the other the Recent flood plain. The cutting of these younger plains has resulted in the destruction of all but remnants of the original Okefenokee plain.

The Okefenokee fluviatile deposits overlie in turn all the older Coastal Plain formations, from the Cretaceous to the Pliocene. The materials have been derived in part, perhaps chiefly, from these older formations, and in part from the Piedmont Plateau region to the northward of the Coastal Plain. On account of lithologic similarity it is sometimes difficult to distinguish between the terrace deposits and the underlying older formations. However, in most cases a gravel bed is present at the base of the terrace deposits, and unconformable relations to the older deposits appear wherever there are clean cut exposures. It is probable that in the past some of these deposits have been confused with the Altamaha formation as has been pointed out in the discussion of the Lafayette formation.

The deposits consist chiefly of red, argillaceous sands, in places pebbly, and coarse gravels. There are but few clay beds and the formation lacks the distinctive alluvial character of the lower terrace and flood plain deposits. Along some of the streams a gray, incoherent, rather pure sand seems to be the only deposit. Near the Fall Line the deposits show clearly that they have been derived in large part from the crystalline rocks of the Piedmont region, but farther south the Coastal Plain formations have contributed a major portion of the materials. Along Withlacoochee, Allapaha, and Ocklockonee rivers the detritus has been derived entirely from the Coastal Plain formations. The formation is usually unconsolidated but in a few places there are local beds of gravel cemented by iron oxide. The pebbles are chiefly quartz and quartzite, but a subordinate percentage are limestone, flint, and limonite.

At a number of localities on the Okefenokee plain there are sur-

ficial, brown-gray, loose, incoherent sands differing in their physical appearance and lithologic characters from the red loams and gravels forming the terrace deposits, and resembling closely the gray sands of the upland. Conspicuous accumulations of such sands were noted at Montezuma, Bainbridge, Fort Gaines, Dublin, and Lumber City. Some of these deposits are in the form of hills and are probably of wind-dune origin; they may have been formed subsequent to the elevation of the terrace plain. At other localities the gray sands appear to be water-laid sediments which rest directly upon the older formations, forming a thin uniform mantle over the plain.

The formation is thin, not exceeding 50 feet at any place, and usually much less than 20 feet. The greatest thickness was noted near the Fall Line.

Except for fragments of silicified wood found at Fort Gaines, and fossils in limestone and flint pebbles derived from the underlying Tertiary beds, no fossils are known in this formation.

The deposits are confined to comparatively level plains paralleling the rivers. The plains were originally one to 10 miles in width, but the deposits have been so largely removed by subsequent erosion that their total area is relatively small. They are confined principally to the courses of Chattahoochee, Flint, Ocmulgee, Oconee, Altamaha, Ogeechee, Savannah, Ocklockonee, Withlacoochee, Little, and Allapaha rivers.

At a few localities the terrace plain forms a conspicuous topographic feature. The physiography of the terrace is illustrated in a profile accompanying this report (See fig. 2, p. 37). The business portion of Macon, a part of the residence portion of Columbus, the cities of Fort Gaines, Albany, Lumber City, and parts of Augusta are built on this terrace.

In detail the surface of the terrace is nearly level, the only undulations being due to sand heaps. The vegetation is more luxuriant and the soil generally more fertile than on the interstream uplands.

The approximate elevations of the second, or Okefenokee terrace plain, above sea-level at the Fall Line are:

	River.	Terrace Plain.
Augusta	98	200
Milledgeville	215	290
Macon	279	355
Flint River at Fall line	320 ?	380 ?
Columbus	190	300 to 325

From the Fall Line there is a gradual descent, until the river terraces merge into the coastal sand plains bordering the sea coast.

LOCAL DETAILS

Chattahoochee River.—Good exposures of the Okefenokee formation occur in the valley of the Chattahoochee at Columbus, and Omaha, Ga., at Eufaula, Ala., Fort Gaines, and at Columbia, Ala.

At Columbus, Muscogee County, the deposits lie on a terrace approximately 100 to 125 feet above the river. They consist of bright red, highly ferruginous, clayey sands, and gravel composed of large, well-rounded quartz pebbles or cobbles. The formation is exposed at Rose Hill, Ga., and in Phoenix, and Girard, on the Alabama side of the river. It rests unconformably upon the Cretaceous and Crystalline rocks. The deposits do not exceed 30 or 40 feet in thickness.

In the vicinity of Eufaula, Barbour County, Ala., the second terrace deposits appear in a bluff of Chattahoochee River, and form a level plain lying about 100 feet above the river. Upon this plain the greater part of the city of Eufaula is built. The formation rests unconformably upon the black clay-marls of the Ripley formation. The surface materials are massive, highly ferruginous, clayey sands, slightly hardened by atmospheric agencies, resting upon heavy beds of gravel. The gravels are made up chiefly of quartz pebbles. About one mile southeast of Georgetown, Quitman County, Ga., the gravels have been mined in a pit near the Central of Georgia Railway. Here the deposits are a heterogeneous mixture of gravel and red sand, in places indurated to such an extent as to require blasting. About 15 feet is exposed in the pit. The pebbles are small and consist chiefly of vein quartz material.

At Fort Gaines, Clay County, the second terrrace deposits consist principally of coarse, red, clayey sands with quartz pebbles at the base. They rest upon Eocene strata. A thickness of 25 feet was noted in this vicinity. In places large limestone fragments, evidently derived from the Midway formation (Eocene), occur in the base of the deposits. The pebbles are composed chiefly of subangular quartz; they are poorly stratified, being arranged in oblique lines and showing crossbedding. Good exposures occur at the old Brown Mill, one mile north of town. Fragments of silicified wood were noted which probably came from this formation. In this vicinity loose, structureless, gray sands also appear on the terrace plain.

At Columbia, Ala., and vicinity, the deposits consist of highly ferruginous, red, clayey sands with scattered small pebbles. The sands have a distinctive bright red appearance, and, upon exposure to the atmosphere, harden in a peculiar manner. The sands form a plain about 100 feet above the river level upon which the town of Columbia is built.

Flint River.—The deposits along Flint River lie 50 or 60 feet above the river and consist of coarse, red sands and gravels. The gravels, which consist of small pebbles, form the lesser part of the deposits. The sands contain some disseminated clay, and when weathered present a mottled appearance. A covering of gray sand is conspicuous over the second terrace from the vicinity of Newton southward; the plain here reaches a greater width than along any of the rivers. The upper part of Red Bluff on the west side of the river, seven miles north of Bainbridge, presents an exposure of Okefenokee sand lying unconformably upon a mass of residual flint and clay derived from the Vicksburg and Chattahoochee formations. The deposits vary from 6 to 29 feet in thickness; at the base they consist of coarse sands and small quartz pebbles with a few limestone and flint fragments; the upper part is composed of red, massive sand with sufficient clay to produce a mottled effect when weathered. On the west side of the river, and extending three or four miles northward from Bainbridge, is a conspicuous development of wind-blown sand upon the second terrace.

Ocmulgee River.—Along Ocmulgee River deposits were recognized at Macon, Lumber City, and other points. At Macon they occur on a terrace 60 to 75 feet above the river, and form the plain on which the business section of Macon is built. They consist of coarse quartz gravels and red, clayey sands containing fragments of siliceous limonite. The deposits are kaolinic in places, the source of the kaolin being in part the crystalline rocks which outcrop in the valley just to the north of the city, and in part the underlying Lower Cretaceous deposits. The beds are heterogeneous, show very little sorting, and present evidence of rapid deposition. At one point in a cut of the Georgia Southern and Florida Railway, near H. Stevens Sons' Company's sewer-pipe plant, a bed of sandstone and conglomerate is prominent. The terrace deposit is easily distinguished from the underlying Cretaceous materials by its darker color and its coarser texture. Its thickness can hardly be more than 20 or 25 feet. An exposure showing the relations between the Cretaceous materials and the terrace deposits occurs in the bluff a few hundred yards south of the plant of the Cherokee Brick Company; white, micaceous, kaolinic sand is overlain unconformably by 15 feet of crossbedded, vari-colored sand and gravel. Lying from 150 to 200 feet above the river are beds of gravel and red, argillaceous sands similar to those on the second terrace, but there is reason to believe that these are remnants of overlapping Eocene deposits.

The terraces are inconspicuous at Hawkinsville and Abbeville and exposures are poor. The formation seems to consist of red sands

with subordinate amounts of gravel. The plain lies about 60 feet above the river and is covered with loose, gray sand.

At Lumber City the Okefenokee terrace is present as a well developed plain about one mile wide on the north side of the river. The terrace deposits are exposed in the upper part of the river bluff. The materials are coarse, gray and red, pebbly sands with coarse quartz pebbles at the base. Among the pebbles were noted fragments of limestone derived from adjacent older formations. The formation probably does not exceed 20 feet in thickness; the surface of the plain lies 40 to 50 feet above the river. The Okefenokee plain is here covered in part by deposits of yellowish, incoherent sand heaped up, in places, probably by wind action.

Savannah River.—The Pleistocene terraces are well developed at Augusta, but there are no sharp demarcations between the deposits on the second terrace and those on the adjacent upland. On the Carolina side at 80 to 100 feet above the river, bright red, ferruginous sand overlies, unconformably, Cretaceous strata and weathered schists, but exposures of red sand probably of Eocene age but of similar lithologic appearance occur in the slopes to an elevation of 200 feet above the river. A mantle of loose, gray sand, slightly tinged with red, also appears on the slopes between the second terrace and the adjacent upland. On the Georgia side near Monte Sano a bed of red, clayey sand containing scattered quartz pebbles and fragments of siliceous limonite was observed lying unconformably upon arkosic sands and clays of the Lower Cretaceous. On account of its lithologic character and topographic position the deposit is considered referable to the Okefenokee formation. These also resemble red sands on the upland at Monte Sano, which probably correspond to the supposed Eocene sands on the upland east of Augusta in South Carolina.

Along the lower course of Savannah River the terrace deposits lie 50 to 60 feet above the river, and consist of gray, brown, and red, almost structureless, unconsolidated sands, and beds of gravel made up of quartz pebbles. The deposits are thin and not conspicuous.

Ogeechee River.—Second terrace deposits appear along Ogeechee River but there are few exposures. They consist of a few feet of red sandy loam, often pebbly, overlain by a thin veneer of gray sand. The plain is 30 to 40 feet above the swamp level. The second terrace is well defined at Millen; the surface is 30 or 40 feet above the river; here the terrace deposit consists of red, clayey sand containing small, angular, quartz pebbles.

Other rivers.—Along Withlacoochee, Little Allapaha, and Ocklockonee rivers, the Okefenokee terrace deposits consist chiefly of non-

pebbly sands, clay being almost entirely absent. The sands are brown or gray, often pure white, and are generally coarse and subangular. The terraces lies about 40 feet above the rivers. The sand deposits average about 10 feet in thickness. They are unconsolidated and massive, except at a few points where pebbles and faint stratification lines were observed near the contact with the older formations.. This sand forms level plains which may reach two or three miles in width. The predominance of sand on these terraces is explained by the fact that the above mentioned rivers have their sources within the Coastal Plain and traverse only older formations consisting predominantly of sand.

SATILLA FORMATION

The name Satilla is derived from Satilla River, Ga., and is applied to the latest Pleistocene deposits of the State. These deposits are typically developed along either side of Satilla River in Camden and Charlton counties. The shore-line during this submergence was parallel to that of the present Atlantic coast, but 20 to 30 miles farther inland. The greater parts of Camden, Glynn, and Chatham counties, all of McIntosh County, the southern part of Bryan County, and the eastern part of Liberty County were submerged, while the valleys of the larger rivers were inundated as far as the Fall Line. There were thus two types of deposits formed, coastal marine deposits and fluviatile or river terrace deposits. The two types will be described separately.

COASTAL TERRACE DEPOSITS

The coastal deposits lie upon a wave-cut terrace which extends 20 to 30 miles back from the present ocean at elevations of 15 to 40 feet above sea-level. The western limit of this terrace or plain is marked by the high sand ridge east of Folkston, Charlton County, and by the escarpment at Waynesville and Mount Pleasant, Wayne County, and at Walthoursville, Liberty County. North of Liberty County the escarpment is not so pronounced as to the southward, and owing to the lack of topographic maps has not been traced in detail. However, it probably passes close to Clyde, Bryan County, Meldrim, Effingham County, and Meinhard, Chatham County. This terrace is in this report, referred to as the "first marine terrace" or "first Pleistocene plain," and is not to be confused with the Recent analogous plain now in process of formation which is represented by sand beaches and tide marshes.

The deposits on the Satilla plain rest unconformably upon Pliocene or Miocene strata, concealing the latter from view, except where ex-

posed along stream bluffs and banks. No sharp distinction can be drawn between the latest Pleistocene and the Recent deposits.

The relative age of the formation with respect to the older Okefenokee formation is determined by its topographic position and not by its stratigraphic sequence or paleontologic evidence.

The formation consists of greenish and bluish, marine clays; gray, white, and yellow sands; and thin layers of gravel. None of the deposits are consolidated.

The clays are fine-textured, and appear to have been muds deposited in lagoons or tidal marshes. They are calcareous in places and contain oyster shells and white calcareous nodules. They also contain organic remains in the form of disseminated, decayed vegetation, stumps of trees and bones of animals. Gypsum crystals were noted in deposits at Savannah and at Colerain Bluff on St. Marys River in Camden County. The clays are usually massive and show few traces of lamination or bedding. They are underlain by sands and often by thin beds of well-rounded quartz pebbles, apparently of beach origin. The sands cover the greater part of the plain and form bluffs on the coast. At the surface they are gray or pure white, becoming yellowish, brownish, or even black at depths, the color being due to iron oxide and disseminated organic matter. They are composed almost entirely of sharp, angular, quartz grains, and are, perhaps, on the whole, finer than the gray, surficial sands of the higher plains. A small amount of mica and black sand, magnetite, ilmenite, and other black, silicate minerals were noted. They show evidences of stratification and crossbedding, and contain shells or prints of shells. In a few places the sands are slightly indurated by an iron oxide cement, as at the bluff near Crescent, McIntosh County.

The sands and clays are closely associated and are contemporaneous deposits.

The maximum thickness of the deposits is perhaps not more than 50 feet and the average not more than 15 feet. A thickness of 22 feet of clay has been observed near Savannah and 20 feet of sand appears at Crescent. At Rose Bluff, Fla., opposite St. Marys, the bluff, which at low tide is 45 feet high, exposes Pleistocene strata referable to this formation from base to top.

The formation is fossiliferous and in this respect is in contrast to the older and topographically higher Okefenokee formation. Shells, mostly living species, are common in places; remains of mammals, megatherium, tapir, horse, mammoth, beaver, deer, and cetacea occur; sharks' teeth occur at certain localities, and remains of a species of crocodile is found. Buried stumps are found in many

places, but no other plant remains of paleontologic value have been discovered.

A collection of bones and teeth made from the dredging at Brunswick were studied by Mr. J. W. Gidley, of the Smithsonian Institution. He says:

"The materials from Brunswick, Ga., consist for the most part of fossil fragments of various mammals and fishes representing species of early Pleistocene age. The sharks teeth, however, probably represent Eocene and Miocene species. The recognizable genera and species are as follows:

Mammals.

Equus fraternus Leidy
Equus ? complicatus Leidy
Equus ? tau Owen (or more probably an undescribed species)
Mammut floridanum (Leidy)
Physeter ? vetus Leidy or Physeterula ? neolassicus
Megatherium sp. probably M. americanum
Castoroides ohioticus
Bison ? bison Linn.
A Cervuline, probably belonging to the genus Cervus
Tapirus haysii Leidy

Fishes.

Sharks—several species of the genera Carcharodon
Galeocerdo and Lamna
Sting-ray—Pastinaca sp.
The sharks teeth represent several species of the genera Carcharodon, Galeocerdo, and Lamna.

Reptiles.

Crocodilus sp.

The "Eocene and Miocene species" may be detrital material redeposited during the Pleistocene.

A collection of shells was made at Rose Bluff, Fla., opposite St. Marys, Camden County, from which the following forms were determined by Dr. Vaughan.

List of fossils from Rose Bluff, Fla., opposite to and four miles southwest of St. Marys, Ga.

Mulinia lateralis (Say)
Terebra dislocata Say
Olivella mutica Say
Nassa acuta Say
Turbonilla sp.
Neverita duplicata Say
Natica pusilla Say
Sigaretus perspectivus Say
Nucula proxima Say
Arca incongrua Say
Ostrea virginica Gmel.
Anomia sumplex Orb.
Phacoides multilineatus (T. & H.)
Divaricella quadrisulcata Orb.
Cardium robustum Solander
Tellina (Angulus) sayi Deshayes
Strigilla flexuosa Say
Donax fossor Say
Donax variabilis Say ? young
Ervilia concentrica Gould
Labiosa canaliculata Say

Sir Charles Lyell[1] visited several localities along the coast of

[1] Travels in North America.

Georgia. He notes finding the tooth of a *Mylodon* and the grinder of a mastodon at Heyners Bridge, 12 miles south of Savannah; he also mentions finding remains of *Megatherium* in the old Brunswick canal and on Skidaway Island. Lyell suggests that the deposits are of fluvio-marine origin and that the bones of the mammals were carried down by streams.

Oyster shells are found in the clay deposits west of Savannah, in clay in the western part of Glynn County, in the clay terrace bordering St. Marys River, and at other localities. Large bones of mammals have been found at Whiteoak, Camden County.

The time which has elapsed since the emergence of the Satilla plain from below sea-level has been relatively short and erosion has as yet affected the appearance of the surface but slightly. The plain is very flat and there are great stretches of swamp land. In places on the plain there are low ridges of sand, probably of beach and wind-dune origin, although some such ridges may have existed as banks or islands previous to the emergence of the plain above sea-level. The clay flats probably represent the sites of old marshes and shallow estuaries and straits.

If the coast region were uplifted 15 or 20 feet above its present elevation, a plain now submerged beneath the ocean waters would appear as an emerged terrace lying east of and parallel to the Satilla terrace, and separated from it by an escarpment. This plain would be analogous to the Satilla plain in all its essential features.

LOCAL DETAILS

Observations have been made at the following localities:

Savannah, Chatham County.—A thick deposit of fine-grained, plastic clay occurs near the Seaboard Air Line Railway, three miles west of Savannah. It is at a lower elevation than the land both to the east and west, and has the appearance of having been deposited in an ancient marsh or lagoon. The clay rests upon red sand and clay of an entirely different lithologic appearance, the age of which is problematical.

At a point one and one-half miles west of this locality, and near the railroad, the clay, as determined by an auger boring, reaches a thickness of nine feet and is underlain by three feet of coarse gravel and sand. The clay is fine-grained, plastic, and contains small lime nodules and fragments of oyster shells.

In a railroad cut seven and one-half miles west of Savannah is a yellowish, stiff, fine-grained clay containing oyster shells. The cut is three feet deep and affords only a poor exposure.

Near Pooler a clay deposit, which is being used in the manufacture of brick, contains oyster shells; buried tree stumps are also reported. The oyster appears to be *Ostrea virginica,* a species at present inhabiting Atlantic Coast waters. The clay lies in swampy, wet tracts and is three to eight feet thick.

At Wheat Hill on the Seaboard Air Line Railway, five miles north of Savannah, 10 feet of bluish, sticky mud containing oyster shells was found by boring.

At the Isle of Hope a bluff eight feet high exposes brownish sand resembling burned sugar; the sand shows crossbedding, is slightly indurated, and contains a few scattered shells.

A large part of the city of Savannah is built on a high, Pleistocene sand bluff or sand hill, surrounded on all sides by lower land. This bluff rises about 30 or 35 feet above the level of Savannah River. The escarpment between this sand deposit and the more recently formed marsh or tide land is easily distinguished near the Tybee Island station of the Central of Georgia Railway in the eastern part of the city.

A bluff on Savannah River a short distance above "The Hermitage" is about eight feet high and shows the following section:

Section in bluff on Savannah River.

	Feet
Satilla formation.	
3. White or gray, incoherent, quartz sand . . . . . }	6
2. Bluish, sandy clay, weathers reddish . . . . . }	
(Unconformity.)	
Age (?)	
1. Gray sand containing white or drab clay laminae	2

Layer No. 1 may represent a formation older than the Satilla formation. No fossils were found. Northward from this point the marine terrace deposits merge into the fluvio-estuarine or fluviatile deposits of the lowest terrace bordering Savannah River.

Southward from Chatham County, through Bryan, Liberty, and McIntosh counties, the surface is covered largely by gray or white sands, with subordinate areas of clays which contain oyster shells.

Crescent, McIntosh County.—A picturesque sand bluff 20 feet high occurs at the mouth of Sapelo River near Crescent. The sand is gray or white at the surface and yellow or brownish at depths; it is sufficiently indurated to produce a nearly vertical cliff, and large wave-worn boulders of the material lie along the base. The induration is probably due to iron oxide cement and the dark color is in part at least due to organic matter. Only faint evidence of stratification was noted. No fossils were discovered.

A red, argillaceous sand of problematic age was seen along the railroad about three miles west of Crescent.

Glynn County.—The Satilla formation in the western part of Glynn County is represented by clays underlying "clay flats" and swamps. The swamp areas probably are the sites of old sounds, marshes and drowned river courses in which chiefly muds were deposited. The surface of the eastern part of the county is mainly sand.

In the bed of a small creek on the Livingston plantation, 18 miles west of Brunswick, the Pleistocene consists of a few feet of greenish-gray, argillaceous sand containing fragments of bones and teeth.

Remains of mammals[1] were found in the excavations for the Brunswick canal in 1838 and 1839, and oyster shells are found in the clay deposits in the western part of the county. Fossil remains from the Pleistocene at Brunswick, obtained by dredging, have been described on page 436.

A short distance west of Bladen and Everett City the rise from the swampy flats of the first terrace to the sandy pine plain of the second terrace may be easily observed without the aid of topographic maps.

Camden County, Satilla and St. Marys Rivers.—At Whiteoak, near the station, a few feet of clay appears just above the level of high tide. The clay is an olive green in color, very sandy, and contains white, limy concretions. Bones of vertebrates have been found. A clay flat extends northward from Whiteoak to Bladen.

Pleistocene clay and sand deposits occur along Satilla River. On the west side of the river at Burnt Fort is a clay flat or terrace nearly four miles wide. The clay of this terrace is greenish in color and stiff, and contains calcareous nodules. The surface of the flat is 10 or 15 feet above the river. The clay overlies a soft, argillaceous limestone and an older sandy clay which are exposed in the river bank at low tide.

At Owens Ferry farther down the river the Satilla formation appears in a bluff about eight feet high. It consists of sand and bluish, sandy clay, becoming coarse-grained, and containing a few scattered pebbles at the base. It overlies a fossiliferous, calcareous sand and sandstone which are tentatively referred to the Miocene.

Over most of the southeastern part of Camden County the only material exposed is gray or yellow, unconsolidated sand.

There are a number of low sea bluffs near St. Marys in which sand only is exposed. Point Peter Bluff, four miles northeast of St.

[1]White, George, Statistics of Georgia, 1849, p. 283.

Marys, is 10 or 12 feet high; the upper part of the bluff is composed of gray, almost white, incoherent sand, and the lower part is brown, chocolate, or almost black, slightly indurated sand.

Miller Bluff on North River, five miles north of St. Marys, is 15 feet high at low tide and is likewise composed of fine sand. The lower part of the bluff is brown or umber in color, and slightly indurated.

A collection of fossils was made at Rose Bluff, Fla., opposite to and four miles southwest of St. Marys. The bluff is composed entirely of sand.

Section of Rose Bluff, opposite to and four miles southwest of St. Marys.

		Feet.
Satilla formation.		
8.	At the top, gray or white, loose sand	3 or 4
7.	Brownish sand, color due to organic matter and iron; compact enough to form large tide-washed boulders	12
6.	Greenish, sandy clay	4
5.	Brown sand contains scattered shells	5
4.	Bluish, stick mud	2
3.	Greenish clay and sand	4
2.	Friable sand, full of shells	5
1.	Sand and greenish clay at low tide	9

The above section was made at a spring, the only point where fossils were found.

A similar bluff, Reeds Bluff, about two miles above Rose Bluff, is described by Sellards.[1] A bed of oyster shells occurs here.

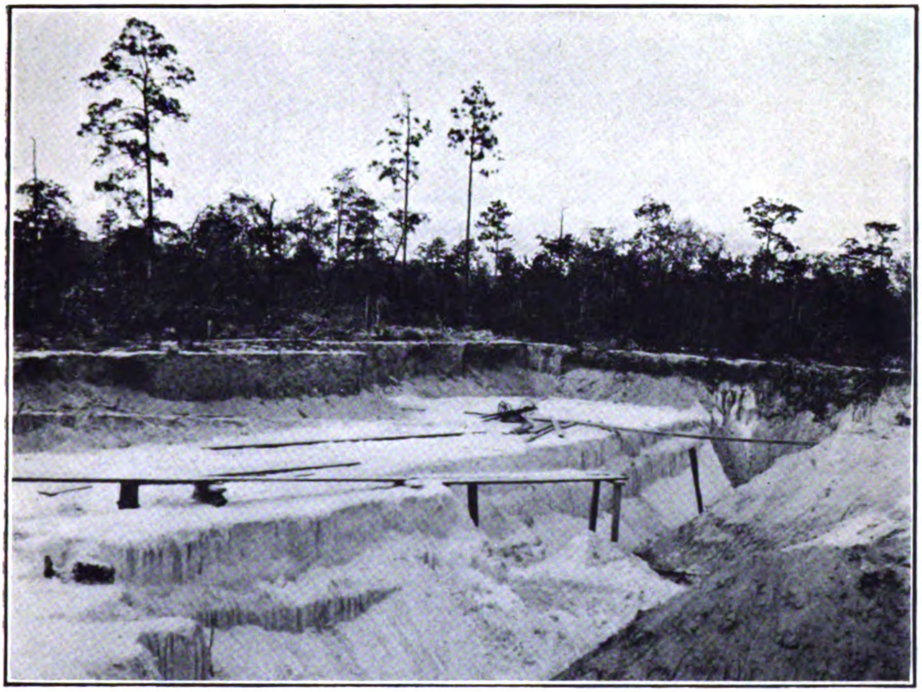
The Satilla formation is exposed at Orange and Chalk bluffs and other localities on St. Marys River, where the deposits underly flat terraces. The best exposures are on the Florida side of the river.

At Orange Bluff, two miles above Kings Ferry, Fla., the formation is a stiff, greenish clay overlying a white marl unconformably. The contact between the clay and the marl (Charlton formation) is marked by a line of well-rounded quartz pebbles, some as large as an inch in diameter. The formation has a thickness of four to six feet in the bluff; a few fragmentary oyster shells were noted in the clay.

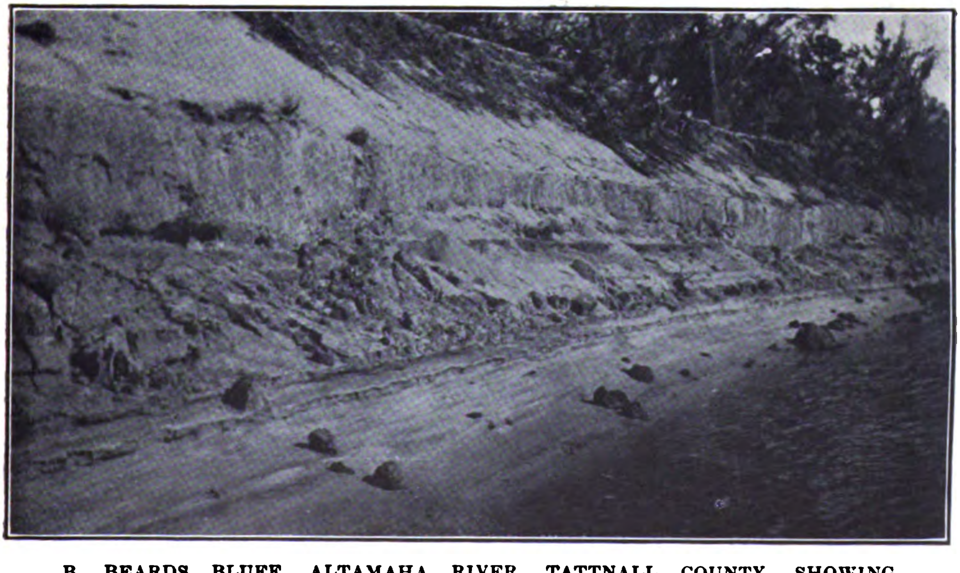
Stiff clay of the Satilla formation was also noted at Chalk Bluff, one-half mile above the preceding.

At Sawpit Landing, two miles above the ferry at Traders Hill, Charlton County, a similar greenish clay forming a flat terrace is exposed in a low bluff to a thickness of three feet. For a section of this bluff see page 398.

[1]Sellards, E. H., Third Ann. Rep't., Fla. Geol. Surv., 1910, p. 127.



A. DEPOSIT OF PURE WHITE SAND USED IN THE MANUFACTURE OF GLASS. PROBABLY BELONGING TO THE OKEFENOKEE FORMATION, TWO MILES NORTHEAST OF LUMBER CITY, TELFAIR COUNTY.



B. BEARDS BLUFF, ALTAMAHA RIVER, TATTNALL COUNTY, SHOWING PROMINENT CLAY LAYER IN SATILLA FORMATION, OVERLAIN BY LOOSE SAND.

FLUVIATILE TERRACE DEPOSITS

The fluviatile deposits of this period form low terraces along the larger rivers of the Coastal Plain. They consist of unconsolidated sands, clays, and gravels which merge coastward into the marine or fluvio-marine deposits described on preceding pages.

The river terraces of the Satilla formation are comparatively flat plains, from 10 or 15 to 40 or 50 feet above the rivers, and vary in width from 300 or 400 yards to an original width of 8 or 10 miles. They extend from the Fall Line southward and eventually merge into the marine terrace plain of the same formation. The greatest width is attained along the lower course of Savannah River, but the river is cutting into this original terrace and forming the Recent alluvium. The topographic position of the terrace is illustrated in Plate II, B, opposite page 40. A distinction is made between the Satilla terrace and the Recent flood plain.

The Satilla deposits overlie Cretaceous and Tertiary formations unconformably. They vary in elevation above sea-level from about 300 feet at the Fall Line to 20 or 30 feet where they merge into the coastal deposits. The thickness does not generally exceed 10 or 20 feet, but a thickness of 40 feet is attained in places.

Lithologically, the deposits vary considerably on the different rivers. On the whole they have a distinctly fluviatile or alluvial aspect, consisting of clays, sands, and gravels, generally unconsolidated, and without regular bedding. The materials have been derived in part from the adjacent older Coastal Plain formations, and in part from the Piedmont Plain region to the northward. Sand heaps, probably wind accumulations, were noted at a number of places on this terrace.

The formation contains but little of paleontologic interest. A few mammalian bones were found at the base of the deposits on St. Marys and Suwanee rivers; a few fragments of silicified wood have also been observed.

Savannah River.—The Satilla plain or terrace bordering the Savannah River was originally a comparatively level plain, two to ten miles in width, which extended entirely across the valley. Into this plain the river has intrenched itself, meandered, and formed a broad, flood plain swamp of Recent age. Throughout the greater part of its course, from about 30 miles below Augusta to Purisburg, S. C., the river banks, exclusive of the high bluffs, expose chiefly the flood plain alluvium of the Recent swamp, the Pleistocene alluvium appearing at but a few localities.

At Augusta the deposits reach a thickness of 30 or 40 feet. They

consist of sands, gravels, and lenticular layers of sandy and plastic clays. The clays are used extensively in the manufacture of common building brick. The business portion of Augusta is built upon the plain formed by these deposits.

New Savannah Bluff, 13 miles below Augusta, affords a fine exposure of the formation. The bluff reaches a maximum height of 25 feet; the lower part consists of coarse, crossbedded sand and beds of small pebbles. A large percentage of the pebbles is composed of feldspar; the upper eight feet is red, coarse, harsh sand which contains a small amount of disseminated clay, and is sufficiently compact to form an abrupt face. At the upper end of the bluff there is a thin, non-persistent layer of bluish-white, sandy clay. The material exposed forms a level plain about one mile wide on the Georgia side of the river.

Silver Bluff, 27 miles below Augusta, on the Carolina side, is the most typical Pleistocene bluff exposed on the river. It furnishes an excellent example of a fluviatile or fluvio-estuarine deposit. The materials consist of coarse, crossbedded sands and gravels of a heterogenous character, overlain by an undulating, massive, and non-laminated sandy clay, and this in turn by red and yellow sands. The pebbles are angular and occur in lenses about three feet thick. None of the beds are indurated. The bluff reaches a height of 22 feet. Opposite, on the Georgia side, the low silty banks of the swamp or Recent flood plain appear.

Other exposures of the Satilla formation occur at Cohens Bluff Landing, S. C.; Poor Robin Landing, Ga.; Parachuchla, and Purisburg, S. C. At Cohens Bluff, 101 miles above Savannah, a bed of massive, light greenish clay, containing lime nodules is exposed. Its lithologic character indicates that it has been derived in large part from the argillaceous Eocene marls to the northward. At Parachuchla, 55 miles above Savannah, the bluff exposes about 15 feet of structureless, gray, and light buff sand, underlain by two or three feet of mottled, sandy clay. The sand forms an oval hill produced by either wind or current action; the type of deposit is similar to that at Beards Bluff on Altamaha River described on a subsequent page. At Purisburg, S. C., 23 miles above Savannah, the formation appears in a bluff about 12 feet high in which is exposed reddish, sandy clay (color due to weathering), drab, laminated clay, crossbedded sand, and coarse gravel resting unconformably upon Miocene strata. The pebbles, which have a maximum diameter of six inches, indicate a fluviatile or estuarine deposit; the coarseness of the gravel suggests that the material was carried down during floods, or at some stage when there were strong currents.

Ogeechee River.—Along Ogeechee River, dposits of the Satilla formation consisting mainly of sand form a terrace, the upper surface of which lies about 10 feet above the river. At Rocky Ford, Screven County, however, clay probably belonging to this formation was noted in a terrace which lies about eight feet above the swamp. A conspicuous development of the sand occurs at Eden, Effingham County. The highest part of the sand hill west of Eden is nearly 20 feet above the swamp.

Ocmulgee and Oconee Rivers.—The Satilla terrace along Ocmulgee and Oconee rivers rises 10 to 20 feet above the river levels. In many places the terrace is swampy, is subject to overflow, and has the aspect of a Recent flood plain deposit.

Near the Fall Line, clay makes up the greater part of the deposits, the amount of sand increasing to the southward. The general section at the Fall Line is:

At the surface, sandy loam grading into brownish or yellowish clay with limonitic concretions; then bluish, plastic clay; and at the base, sand and gravel, water-bearing.

Southward the plain is covered at many places with loose, gray sand, and the clays occur as lenticular beds of small extent, or in pockets in the sand. In places the clays are fine-grained, plastic, and contain lime nodules.

Altamaha River.—Along Altamaha River the Satilla formation presents much the same aspect as along Savannah River. The Satilla plain originally had a maximum width of four or five miles; into this plain the Altamaha River has entrenched itself, meandered and formed an extensive Recent flood plain or swamp two to six feet above low water level. The Satilla beds appear in bluffs 10 to 15 feet high. Hillocks of wind-blown sand appear at different places over the terrace plain.

Beards Bluff (see plate XXIX, B), in Tattnall County, 60½ miles below the forks, affords a good example of the fluviatile phase of the formation. The bluff is about 15 feet high and is capped by a dome of fine, gray sand; beneath the surface sand is an undulating layer of bluish, sandy clay, and beneath the latter, forming the base of the bluff, is a coarse, current-bedded sand. The surface sand seems to have been accumulated by wind action. The clay and lower sand were probably reworked from the Altamaha formation. Ohoopee White Bluff, 39½ miles below the forks also presents a good section of the Satilla formation. The section is similar to that at Beards Bluff except that the wind-blown surface sand does not appear. A coarsely arenaceous clay bed, which terminates abruptly along the

bluff, appears in the section. The materials as a whole are heterogenous in character and appear to have been deposited by rapid river currents. Buckhorn, Red, and Town Bluffs expose materials, mainly sand, referable to this formation.

Flint River.—Near the Fall Line the first terrace above the river is broad and swampy, and is underlain mainly by brownish and bluish plastic clays. From Oakfield to Bainbridge the Satilla terrace forms a narrow plain, 15 to 20 feet above the river. The terrace deposits are exposed at a number of places. The general section is as follows: At the surface—loose, gray sand; then undulating layers and pockets of clay; at the base—coarse, heterogenous, crossbedded sand with lesser amounts of gravel.

Chattahoochee River.—The best development of the Satilla terrace occurs along the Chattahoochee River. The river has cut a narrow trench about 40 feet deep in the nearly level plain, exposing unconsolidated sands, clays, and gravels of the Satilla formation, resting upon strata of Tertiary and Cretaceous ages. Conditions differ from those on Savannah and Altamaha rivers in that there is scarcely any swamp bordering the river, and the plain is on the whole higher above the river level; tributary streams enter the river through narrow trenches or gorges and not through swamps, as on Savannah and Altamaha rivers.

Fine developments of the terrace may be seen at Columbus, Omaha, Georgetown, opposite Eufaula, Ala., and at Fort Gaines. This terrace plain reaches a maximum width of three miles but the average is not perhaps more than one or one and one-half miles.

Opposite Columbus the terrace material consists in part of brownish or yellowish, structureless loam presenting somewhat the appearance of loess. The Satilla terrace forms a level plain, approximately one mile wide and about 50 feet above the river, on which a part of the city of Columbus is built.

The deposits consist predominantly of sand; clay layers occur in undulating beds of variable thickness and in pockets enclosed by sand, and gravel beds are common at the base of the terrace deposit. The crossbedding and the general heterogeneous character of the materials indicate rapid changes in the conditions of deposition.

Southward from Columbus the deposits begin to show evidence of being derived in part from the Coastal Plain formations.

Other rivers.—The deposits of this formation bordering the Ocklockonee, Withlacoochee, Allapaha, Suwanee, and St. Marys rivers are composed almost entirely of gray or white sand and gravel, with subordinate clay beds in a few places. The rivers have cut narrow

trenches resembling canals in the sandy terrace plains of the formation. The terrace plains reach a width of one-half mile or more, though usually they are much narrower; their surfaces lie about 8 to 15 feet above the rivers.

Along Withlacoochee River, east of Quitman, the Satilla terrace is about 20 feet above the river and is about one-half mile wide. The sand is pure white in places and might be suitable for use in the manufacture of bottle glass. It is usually fine at the surface but becomes coarser with depth, often showing crossbedding at the base.

On the Allapaha, two miles east of Milltown, the terrace is well developed and is about 15 feet above the river. The section at the wagon bridge is as follows:

Section at wagon bridge two miles east of Milltown.

	Feet.
Pleistocene.	
Satilla formation.	
3. Brownish or chocolate-colored sand, gray or white over the surface of the plain	5
2. Brown or yellow, coarse sand, quartz, and quartzite pebbles; also contains small white pebbles of phosphate	2
(Unconformity.)	
Oligocene.	
Alum Bluff formation.	
1. Greenish, laminated, sandy clay	S

This terrace forms a clay flat west of Stockton.

At Statenville, Echols County, the Satilla formation consists of very pure, gray or white, quartz sand, in places coarse-grained. The terrace lies about 20 feet above the river.

At Bony Bluff, nine miles southwest of Fargo, large, blackened bones and fragments of silicified wood are found in a bed supposed to lie at the base of the formation.

On St. Marys River from near St. George up the valley the deposits of the formation may be considered of fluviatile or fluvio-estuarine origin. They form a flat sand terrace about 12 feet above the river. At Stokes Ferry, 11 miles south of St. George, the basal part of the formation consists of pebbly sand in which are embedded fragments of bones and teeth, and roots of trees.

RECENT

The Recent deposits, or those formed since the close of the Pleistocene or the uplift of the Satilla or latest Pleistocene terrace, and now in the process of formation, consist of: (1) marsh and tide-swamp muds; (2) beach sand and dunes; (3) river flood plain deposits; (4) interstream swamp deposits; (5) certain terrigenous deposits semi-alluvial in character.

The processes by which the Satilla terrace, with its accompanying deposits, was formed are being repeated at the present time along the coast. The Recent terrace which is thus being formed is largely submarine. Beach sands are being laid down on the ocean front, while the courses of the streams entering the ocean are drowned and converted into estuaries, and muds are being deposited in the marsh and tide-swamp land. In the absence of any accurate maps the area of marsh and tide-swamp land along the coast may be roughly estimated at 400 square miles. While observations have not been made at a very large number of localities, the thickness of the Recent deposits in the area inundated by the tides probably does not exceed six feet. The composition of the muds is indicated by the following analysis of a sample from St. Simons Island, made by Dr. Edgar Everhart from a sample collected by Prof. McCallie.

Analysis of mud from St. Simon Island.

Moisture at 100° C.	4.62
Loss on ignition	9.94
Soda, Na_2O	3.06
Potash, K_2O	1.13
Lime, CaO	.40
Magnesia, MgO	1.28
Alumina, Al_2O_3	13.67
Ferric oxide, Fe_2O_3	4.86
Titanium dioxide, TiO_2	1.01
Sulphur trioxide, SO_3	.24
Phosphorus pentoxide, P_2O_5	.22
Chlorine, Cl	1.77
Silica, SiO_2	57.95
Total	100.15

In places the Satilla terrace is separated from the Recent terrace by bluffs 10 to 15 feet high, while at other localities the two merge into each other.

The Recent alluvium along the Coastal Plain streams consists mainly of sand, although along the lower courses of Altamaha and Savannah rivers some clay has been deposited. Owing to the comparatively short period that has elapsed since the close of the Pleistocene, deposits of this class are of small extent. Along some of the streams the only Recent deposits are accumulations of sand in the form of bars.

In the southeastern part of the Coastal Plain of Georgia are numerous swamps ranging in size from one to two acres to that of the immense tract known as Okefenokee Swamp. Peaty accumulations or decayed plant matter with more or less silt and sand are being formed in these swamps. In the Okefenokee Swamp peaty accumu-

lations to the thickness of four feet are reported. Some of the swamp areas are densely wooded and have been the roosting places of birds for perhaps centuries, and a phosphatic muck is being slowly formed from their dung and dead bodies.

Sand deltas or plains of semi-alluvial character form another type of Recent deposits. In the northern, hilly part of the Coastal Plain erosion has been very active on account of the loose, unconsolidated character of the formations; and at certain localities, especially where the forests have been cut away, deep gullies have been formed. Every torrential rain moves large quantities of sand which, on acount of over-loading, is deposited along the beds of the small creeks, forming so-called "sand streams," or is spread out at the mouths of gullies forming small subaerial deltas. The best example of this type is at the huge gullies or "caves" west of Lumpkin, Stewart County. A "sand stream" is illustrated in Plate XIV, B.

SURFICIAL GRAY SANDS OF THE UPLAND

Surficial grayish or brownish, incoherent quartz sands cover large portions of the interstream uplands of the Coastal Plain of Georgia at elevations higher than the Pleistocene terrace plains. On account of the sterility of the soils which these sands produce and their influence on the topography and tree growth, they attract the attention even of persons who are not interested in problems of geology. The sands are not everywhere of the same origin. Much of the sand is residual and can not be referred to any one geologic period or formation. However, in places there are wind-blown accumulations, and at rare intervals the marks of stratification can be detected. In this report no attempt has been made to sub-divide or to map these sands and a part of this work would, perhaps, more properly fall within the province of a soil survey.

The surficial gray sands are made up almost entirely of crystalline quartz there being at no place sufficient clay to render them coherent. A number of samples were examined microscopically. In addition to the quartz grains, small percentages of clay, some limonite and allied iron oxide minerals, and very small amounts of minerals common to igneous rocks such as mica, magnetite, ilmenite, feldspar, and rutile were detected. The clay content rarely exceeds three per cent; the limonite occurs as a coating over the quartz grains and gives the sand its yellowish or brownish appearance. On the whole, the sand is uniformly fine in texture; in samples tested from several localities 40 to 60 per cent. of each sample passed a 40-mesh sieve; the texture of the residual sands at any particular locality depends upon the character of the sands in the formations from which they were de-

rived. In all of the more notable deposits the quartz grains are for the most part subangular. In color the sands are dull gray or white at the surface, but at varying depths becomes yellowish or some darker shade; the darker basal sands grade downward into the underlying, unweathered, argillaceous, sandy formations. Pebbles are not common although at a number of localities they have been observed. They consist of small, well rounded to angular, quartz pebbles, and small, brown or black, iron oxide nodules. Slight differences in the character of the sands at various localities have been noted, but on the whole they are uniform in texture, color, and composition, notwithstanding their diversity of origin.

The surficial sands vary in thickness from a few inches to a maximum of 30 feet. The greatest thickness of what appear to be residual sands occurs at the sand-pits near Howard, Taylor County, where the maximum is 20 or 30 feet. At other localities along the Fall Line 10 to 25 feet of sand has been observed, but over much of the "sand hill' region, the thickness does not exceed five or six feet. Over the Altamaha (Lafayette ?) terrane the average depth of the residual sands in place is probably between two and four feet, but there are local accumulations of sands of torrential or eolian origin reaching a thickness of 10 to 25 feet. In the western part of the Coastal Plain, principally that part underlain by the Vicksburg formation, the gray sands are either absent or very thin. They are absent also in scattered smaller areas in other parts of the upland region.

The surficial sands are present as a thin mantle over parts of the upland region from the Fall Line on the north to the Florida State line on the south. To the southeastward, within 50 or 75 miles of the Atlantic Coast, they merge into the lithologically similar sands which cover the Okefenokee terrace plain. The sands are unequally distributed over the upland and are notably absent from certain areas. Their most conspicuous development is in the Fall Line region, chiefly over the area underlain by Lower Cretaceous strata; they are also well developed over the region underlain by the Altamaha and Alum Bluff formations in the eastern and southeastern parts of the Coastal Plain. Upland areas, where the sands are nearly or entirely absent, are the following: Certain areas in Burke, Washington, Wilkinson, and Twiggs counties which are underlain by red, ferruginous sands of the Claiborne formation; Rich Hill, Crawford County; the Fort Valley plateau, and the "red lands" in the vicinity of Grovania, Henderson, and Elko in the southern part of Houston County; the northern part of Dooly County; in the vicinity of Americus, and the southern part of Sumter County;

large parts of Randolph, Terrell, Dougherty, and other counties west of Flint River; and in the southern parts of Grady, Thomas, and Brooks counties.

The sands, notwithstanding their relatively insignificant thickness, have had a very marked influence upon the topography, vegetation, and settlement of the country. The "sand hills" constitute a well known type of topography in the region of the Fall Line, and throughout that part of the area underlain by the Altamaha (Lafayette ?) formation, popularly known as the "wire-grass" region. In the latter region the sands are most conspicuous along the streams and particularly along those streams having general north-south courses. It has been commonly noted by the people living in this region that the accumulations of sands are greater on the east or left sides of the streams. Numerous exceptions to this may be found in the Coastal Plain region as a whole, but it is prevailingly true over the "wire-grass" region. The hills perhaps antedate the present streams and may have governed their courses in part, the western front having acted as a barrier preventing the streams from pushing their courses to the eastward. The most notable examples of this type of sand hills are on the eastern side of Ohoopee River at Reidsville; on Cannoochee River at Stillmore; on Little Ocmulgee River two miles east of Helena and at Lumber City; and on the north side of Satilla River north of Waycross. These hills are well above the level of the streams and the sand is not to be confused with the alluvial sands of lower levels. The vegetable growth over the sand hills is sparse, consisting mainly of scattered long-leaf pines and stunted oaks, and the soil is poor and unproductive.

The origin of the gray sands which form the "sand hills" and cover the higher interstream areas of the Coastal Plain has been a perplexing problem to geologists and other investigators.

In the few references made by McGee[1] to these surficial sands he referred them to the "interfluvial phase of the Columbia." Also Spencer,[2] McCallie,[3] and Veatch[4] have referred to them in a general way as "Columbia sand." Mr. R. M. Harper[5] has given interesting descriptions of the sands at a number of localities, discussing them from the standpoint of their influence upon the flora of the Coastal Plain.

[1]The Lafayette formation: Twelfth Ann. Rept., U. S. Geol. Survey, 1890-1891, pt. 1, pp. 388, 389.
[2]Spencer, J. W., First Ann. Rept. Progress, Georgia Geol. Survey, 1890-1891, pp. 61-71.
[3]McCallie, S. W., Underground Waters of Georgia: Georgia Geol. Survey, Bull. No. 15, 1908, p. 29.
[4]Clay Deposits of Georgia: Georgia Geol. Survey, Bull. No. 18, 1909, p. 68.
[5]A Phytogeographical Sketch of the Altamaha Grit Region of Georgia: Annals N. Y. Acad. Sci., Vol. XVII, pt. 1, Nov., 1906.

It is reasonably certain that much of the surficial sand is residual from Cretaceous and Tertiary formations, and hence should not be classed as a *formation,* using this word in a stratigraphic sense. The residual sand varies from one to ten feet in thickness. At many places on the slopes there are accumulations of sands transported by rainwater from higher to lower levels. In some cases the redeposited sands appear to rest unconformably upon the underlying strata, this relation being especially apparent where pebbles are present at the base. Such deposits may show a thickness of from five to fifteen feet whereas the residual sands on the tops of the hills may not be more than two feet. Accumulations of this nature are properly colluvial deposits. The winds may have shifted and redeposited the residual sands in places but there do not appear to be many large deposits due to this cause.

The formations from which the residual, surficial sands are derived are themselves composed chiefly of quartz sand with small percentages of disseminated clay. In the process of weathering the clay is carried away in suspension by rainfall leaving the quartz grains and small amounts of other minerals, such as mica, iron oxides, etc. Wherever the formations underlying the surface are very calcareous, argillaceous, or ferruginous, the gray surficial sands are absent.

In addition to the residual and colluvial deposits, there are gray or browish, incoherent sand deposits 10 to 30 feet thick, which lie in belts one-half mile to two miles wide, paralleling certain rivers and creeks; these accumulations appear to be at higher elevations than the fluviatile terrace deposits of the Okefenokee formation. Locally, they exhibit faint stratification lines and in places seem to be sharply separated from the underlying older formations. These facts, together with their peculiar distribution and relatively great thickness are evidence of their non-residual character. Their high elevation precludes the possibility of their having been deposited by existing streams. It is suggested that they may have been heaped up as the result of combined wave and wind action along the shores of early Pleistocene estuaries, or they may have been deposited as alluvium by the rivers occupying the valleys in early Pleistocene time. This type of surficial sand is typically developed along Cannoochee, Ohoopee, Little Ocmulgee and Satilla rivers, and appears along other streams throughout the Altamaha upland or "Wiregrass country."

One well known sand deposit,—the sand hills on the east side of Flint River at Albany,—clearly owes its present form to wind deposition, whatever may have been the primary origin of the sand.

There is some evidence of a sand-coverd, Pleistocene terrace plain higher and older than the Okefenokee plain and perhaps similar in origin, although as yet sufficient proof of its existence has not been obtained to warrant positive statements. Such a plain, if it exists, includes a part of the gray surficial sands here treated under the head of upland sands. (See pp. 424-425.)

LOCAL DETAILS

The more important localities where the surficial sands are developed, are mentioned below, and the topographic positions, lithologic characters, and probable origins of the deposits are indicated.

Fall Line localities.—Extending southward 10 to 20 miles from the southern border of the Piedmont Plain is a belt of land over much of which gray or brownish, incoherent quartz sands form a surficial covering. In a classification of the Coastal Plain from the agricultural standpoint Loughridge[1] has described this region as the "Fall Line sand hills." In extent the "sand hills" were said to reach across the State from Augusta to Columbus, covering an area of about 2,950 square miles. The surficial sands over this area are believed to be residual, except along the terraces bordering the rivers, where fluviatile sand deposits of Pleistocene age have been deposited.

Near Hampton Terrace Hotel on the South Carolina side of Savannah River opposite Augusta, the surficial sands are gray or brownish, and mantle the upland plain at an elevation of 225 feet or more above the river; in one exposure, at the base of the gray sand water-worn, quartz pebbles having a diameter of two or three inches, were observed. These pebbles are unmistakably in the surficial sand and suggest an unconformity with the underlying strata. The sand here overlies red, highly ferruginous sand of Eocene age. The gray sands are also exposed on the Georgia side west of Augusta, at Monte Sano, at which place also a few pebbles were noted. The sands also mantle the hills and ridges westward from Augusta. Notable thin coverings of grayish or brownish quartz sands, probably residual, occur in the vicinity of Grovetown, Columbia County, and are also well developed over the hill tops and slopes southward from this place to Hephzibah, Richmond County. They attain a thickness of only a few feet. In this region the sands are underlain principally by Eocene strata.

At Keysville, in the northwestern corner of Burke County, the surficial sands reach a thickness of 10 to 18 feet and do not seem to be in any way connected with the drainage of the country. The

[1]Loughridge, R. H., Cotton Production: Tenth Census, Vol. 6, p. 38.

sands are in general yellow or brownish, and, when moist, resemble oak sawdust; but in places at the surface they have been leached almost pure white. They consist almost entirely of subangular quartz, but microscopic examination reveals a few rounded grains of opalescent silica; limonite forms a coating over the quartz grains; there is some organic matter at the surface to which the characteristic dull gray appearance is due.. No trace of stratification appears in any of the exposures. About two miles east of the town there is in these sands a circular depression which probably resulted from the irregular heaping up of the sands by wind action. The surficial sands overlie red, argillaceous sands of Eocene age.

About 10 feet of brownish, incoherent sand overlies the Cretaceous strata in the railroad cut at Carrs Station, Hancock County, and similar sands appear at other localities in the southern part of the same county.

In a cut of the Central of Georgia Railway, about three miles west of Griswoldville, Jones County, 10 to 15 feet of loose, surficial sand overlies red Eocene sand from which it does not seem to be sharply separated. Although so great a thickness of sands of the residual class is not common, the nearly pure character of the underlying Eocene sands at this locality renders this explanation of the origin of the deposit the most probable one.

The gray, pebbly sands appear as a thin covering over the high level upland west of Macon, lying about 200 feet above Ocmulgee River. They appear to be residual from the underlying pebbly formation. The gray sands and gravels are mined at a small pit three miles west of Macon near the Columbus road.

The gray sands are well developed southeast of Roberta, Crawford County. They do not appear at all on Rich Hill, which is capped by Eocene strata, and which is probably the highest point in the Coastal Plain; over the adjacent Lower Cretaceous area to the southward they form a thick mantle covering a belt a few miles wide. In this region the sands are gray at the surface, and light yellow at depths, and are composed almost entirely of quartz. The thickness averages four to six feet but locally reaches 10 to 15 feet. At many places in this region the surface is dotted with numerous small, oval hillocks of sand, 8 or 10 inches high, thrown up by a burrowing pouched gopher, locally known as a "salamander." This small rodent is common elsewhere in the sand hills of the Coastal Plain. To the southward of this region in the Fort Valley area the surficial sands appear to be entirely absent.

The best known development of the surficial sands occur on the high plain stretching from three miles east of Butler, Taylor County,

westward to Geneva, Talbot County, in the region traversed by the Central of Georgia Railway. This plain reaches an elevation of 650 feet or more above sea-level. The sands are being excavated for commercial purposes at Howard and Junction City.

Nèar Butler the sands are only five or six feet thick. They extend northward from Butler to the border of the Piedmont area.

At Howard, near the pits of the J. M. Brown Sand Company, the sands attain a probable maximum thickness of over 30 feet. Thirty feet of sands appear in the pits near the railroad, one mile west of Howard. They are entirely unconsolidated and show but little evidence of stratification. At the surface they are gray or light buff in color but in places at depths are slightly darker. These sands overlie Lower Cretaceous strata apparently filling old erosion hollows; although there are these local indications of unconformity it is believed that the sands are residual from the underlying Cretaceous strata, but in places have been shifted into ravines by winds and torrents.

Section in pit of J. M. Brown Sand Company at Howard.

Surficial sand.	
5. At the surface—fine-grained, gray or brownish sand	
4. Light yellow sand	25
3. Almost white sand, showing some evidence of water stratification	
2. Ferruginous sand containing a very small percentage of clay	5
1. White sand	

Microscopic examination of a sample of the surficial gray sand from this locality revealed chiefly subangular quartz grains with slight amounts of mica in fine flakes, some decomposed feldspar attached to quartz grains, minute particles of black sand, and a small amount of iron oxide which forms a coating over the quartz grains; the clay content does not exceed one or two per cent.

Near Junction City, Talbot County, the sands reach a thickness of 20 feet; in color they are light bluff or dull gray; as at Howard, they are composed of subangular quartz with minor amounts of clay, iron oxide, mica, and black sand; they are generally fine in texture but a few rounded quartz pebbles about the size of buckshot were observed in places. The deposits are wholly unconsolidated and reveal no stratification.

Similar sands are present in the region to the southward of the above mentioned places and overlie the Upper Cretaceous and lower Eocene beds. Over a large part of the limestone region of southwestern Georgia they appear to be absent, the soils consisting of

red, argillaceous sands residual from the Eocene and Oligocene formations; they have been noted in a few places, however, as in the region east of Americus, Sumter County; north of Shellman, Randolph County; over a large part of Lee County; in the western part of Baker County; and in Miller County.

Large accumulations of sand appear in the form of dunes 30 or 40 feet high on the east side of Flint River at Albany; the maximum elevations of their summits above the river is about 100 feet. Among the dunes are undrained depressions probably due in part to the collapse of solution caverns in the underlying Vicksburg limestone, and in part to the irregular heaping up of the sand by wind. The sands are gray or light buff in color and are composed entirely of subangular quartz grains; in composition and appearance they resemble the gray sands of the Fall Line region. Small, angular and flat flint chips are scattered through the sands; since these fragments show no evidence of having been water-worn in transportation they are believed to be the chippings left by Indians in the manufacture of arrows, hatchets, etc. Similar flint chips have been observed at Dublin in sand described on a following page. The sands were probably accumulated during the early Pleistocene period.

"Wire-grass" sand hills.—Grayish and brownish sands are present as a surficial covering over nearly the whole of the "wire-grass" upland east of Flint River. Generally they form only a thin residual covering over the mottled, argillaceous sands and clays of the Altamaha (Lafayette ?) formation. The thickness of the sand averages two to four feet, but at a number of localities there are accumulations reaching 10 to 25 feet. A few of the more conspicuous localities are mentioned below:

In the southeastern part of Burke County, and also in Screven County, are heavy beds of surficial gray sand of probable residual origin lying between Briar Creek and Savannah River. The sands reach a thickness of from 3 to 10 feet and overlie, alike, the Barnwell sand of the Claiborne group and the Altamaha (Lafayette ?) formation. They lie on the divide between the two streams at elevations of 125 to 150 feet above Savannah River.

On the east side of Oconee River, opposite Dublin in Laurens County, is a conspicuous accumulation of sand lying about 100 feet above the river and reaching a maximum thickness of 20 feet. See plate XXX, opposite page 448. The sands are gray to light buff in color. Near the surface they are rather fine, incoherent, and structureless, but with depth become slightly coarser and near the base exhibit current bedding. Between this sand accumulation and the river there are gray sands of terrace origin which are certainly of

Pleistocene age and referable to the Okefenokee formation. Quartz pebbles were noted in the upland gray sands south and southwest of Dublin.

A fine exposure of sand appears in a cut of the Seaboard Air Line Railway two miles east of Helena, Telfair County, on the east side of Little Ocmulgee River. The sand bed reaches a thickness of 25 feet; it is gray or light buff in color, becoming coarser and almost white at the bottom of the cut; very coarse sand and a few pebbles were noted near the contact with the underlying formation. The sand hill reaches a height of 75 feet above the river and extends southward to the junction with the Ocmulgee at Lumber City. On the west side of the river only a thin coating of the gray sand is present.

The gray sands are well developed in the region traversed by Cannoochee River and its tributaries. A notable deposit occurs on the east side of Cannoochee River five miles northeast of Stillmore, Emanuel County, where it is well exposed in a cut of the Georgia and Florida Railway. The sands reach a thickness of 15 feet; are gray, yellow, or light buff in color, and have the characteristics of similar accumulations at other localities. Wavy lines one-eighth of an inch thick or less, of ferruginous, darker colored sand, present the only evidence of stratification. At one point in the cut a high percentage of iron oxide was observed, rendering the sands yellow or orange in color; a few thin, limonitic crusts were noted. This deposit is well above the river and is certainly not a Recent flood-plain accumulation. On the west side of the river there is only a very thin film of sand over the Altamaha (Lafayette ?) formation.

Similar deposits occur along the Georgia and Florida Railway on the north side of Ohoopee River, six miles southeast of Stillmore; on the north side of Pendletons Creek; and near Normantown.

Near Reidsville, on the east side of Ohoopee River in Tattnall County, is a heavy sand bed covering a belt two to three miles wide. The sands are white at the surface in places and in a photograph produce the effect of snow. The deposit lies well above the river and apparently is not of river terrace origin. However, gray sands, locally termed "sand hammocks" which are probably of Pleistocene terrace origin, occur at lower levels along the river.

There is an extraordinary development of sand on the east and north side of Satilla River, and its tributary, Seventeen Mile Creek, extending from western Pierce County opposite Waycross, to Douglas, Coffee County. This deposit consists of gray, yellowish or brownish, incoherent quartz sands free from pebbles and clay, and for the most part structureless or showing only very faint structure.

In places the sands reach a thickness of 20 or 30 feet or more. The altitude of the sand hills above Satilla River is about 50 feet, or about the same as the general upland level of the same region. The sands lie at a higher elevation than the sands of the Okefenokee terrace plain east of Waycross, and because of their higher elevation are supposed to be older than that formation. In places in this belt there are in the sands roughly circular, shallow depressions which during rainy seasons, hold water and form sand hill ponds. It is not known whether these sands are of beach and wind-dune origin along the shore of a Pleistocene estuary or whether they were deposited as alluvium. It is certain, however, that they owe their present form in part to wind action.

Considerable accumulations of surficial sand cover the high plateau on the east side of Flint River from near Faceville, Decatur County, southward to River Junction, Fla. The sands are buff or dirty gray in color, due to iron oxide and to a small amount of organic matter from growing vegetation. They are loose in texture and resemble the surficial sands of the Fall Line region and elsewhere. A sample from near the 255th mile-post on the Atlantic Coast Line Railway between Recovery and River Junction was examined microscopically. It was found to consist chiefly of fine, subangular quartz with a small percentage of well rounded, or spherical grains, and a very small percentage of clay.

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